METALLURGIA

The British Journal of Metals

(INCORPORATING THE METALLURGICAL ENGINEER.)

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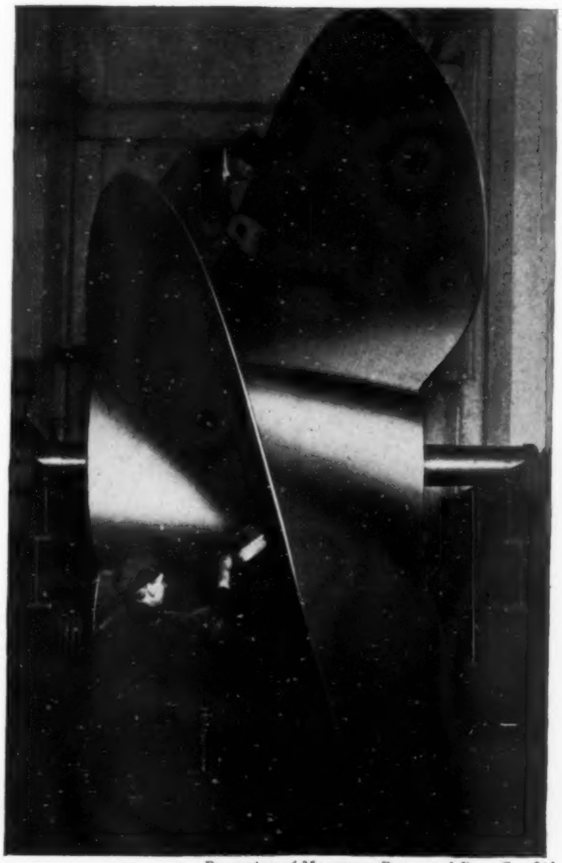
Propeller Manufacture

By WM. ASHCROFT

The last half-century has seen continuous research and experimental work directed towards the improvement of propeller design and manufacture. In this article the author discusses some principles involved, the preparation of moulds and some problems associated with the metals used particularly the high-tensile brasses which have been developed.



By courtesy of Manganese Bronze and Brass Co., Ltd.

Propeller for the Normandie on "the balance." Note lifting lugs left on for handling during transport.

To many foundry men, no work is of greater interest than the making of a propeller; some even regard with awe the various operations involved, particularly those who have had no experience with castings of this type. This is probably due to the fact that propeller making is, as a rule, the work of specialists whose long experience enables them to overcome difficulties presented not only in making suitable moulds, but in mixing and melting the metal, and casting. To the foundryman unfamiliar with the procedure the making of a propeller would seem extremely difficult, but in reality the difficulties are not greater than in many other departments of foundry practice. A study of the screw propeller is absorbing, and once the foundryman has grasped some knowledge of the fundamental principles on which its design is based, a satisfactory procedure can be developed which will enable him to make the mould, though it should not be imagined that the final production of the casting is easy, especially when a high-tensile bronze is used. Many methods are adopted; in this article, however, it is not proposed to describe any of these in detail, but to discuss some principles involved, important features in preparing moulds and some problems associated with the metal used, particularly the high-tensile brasses generally used for passenger and war vessels.

The principle of the propeller does not differ materially from the principle of a worm or spiral wheel. It might almost be described as a multi-threaded worm, sections of the helix of each thread being brought to the same plane and spaced equally around a comparatively small cylinder. The principle is simply that of a screw possessing an abnormally coarse pitch, but the propeller is designed to revolve in water which is more yielding than other materials in which ordinary screws are used, thus the action is not positive and propeller designers must consider the work that is lost by slip, eddy making, and several other factors which need not be discussed here.

The sections of each thread are conveniently shaped to form the leading and trailing edges of each blade, the object being to obtain the highest efficiency in relation to speed of rotation, and to reduce possible vibration. The number of blades is largely a question of expediency and has no all-important bearing on the efficiency of the screw. It is generally considered that a three-bladed propeller has a slightly higher efficiency than a four-bladed one. On the other hand, the four-bladed propeller is frequently preferred, especially when it is of cast iron, because if a blade is broken in service—a not uncommon accident—there is more uniform stress on the shafting and bearing than when a similar accident happens to a three-bladed propeller. This means that a vessel which has an accident to one or two blades of her propeller can carry on better if the propeller was originally four-bladed. This difficulty does not often arise when a high-tensile bronze is used, and the question whether a three- or four-bladed propeller is used is decided after a consideration of other factors.

The pitch of a propeller, or the pitch of any screw, is the distance a point moving along its helical path would advance in a direction parallel to the axis of the screw, in one

(By courtesy of J. Stone & Co., Ltd.)

One of the propellers for the Normandie. Finished weight 23 tons.

revolution, or, it may be expressed more clearly by stating that the pitch represents the distance the vessel would advance from one revolution of the propeller if there was no slip. The majority of propellers are of uniform pitch, and, of the remainder, which have a varying pitch, the pitch may vary axially or radially, or, as in some exceptional cases, they may vary both axially and radially. When the pitch of the propeller is uniform it is called a true screw.

As in the case of ordinary screws, propellers are made both left- and right-handed. A right-handed propeller revolves clockwise, when it is viewed towards the stern of the vessel, to move the vessel ahead. In the foundry, where the working face of the propeller is cast down, if the high side of the bottom of the mould is at the right hand, when looking towards the hub or boss, a right-handed propeller is being made. It is found in practice that propeller blades of the broad-tipped type give the best results when the speed of the vessel is an important factor. Four-bladed propellers of this type are more difficult to mould because the trailing edge of one blade is usually underneath the leading edge of the next blade. This necessitates undercutting the mould to facilitate the lifting of the cover of each blade.

Building The Mould

Loam moulds are invariably prepared for large propellers. It is customary to build these moulds on specially cast plates arranged conveniently for transferring to and from drying ovens. The bottom part of each mould is formed by means of sweeping boards, which constitute the major part of the pattern-work for such a casting, but a race or angle is also an important requisite, which may be made in wood or iron. The simplest form of race is that required for a propeller of uniform pitch. It will be appreciated that although a propeller has a uniform pitch the angle of the helix formed at different distances from the centre will vary. This is readily determined by forming a right-angled triangle, using the circumference of the position on the blade at which the angle is desired, as the base, and the pitch as the height. The race or angle is usually made to occupy a position about six inches from the extreme edge of the blade of the required propeller, so that a suitable joint is formed for the mould.

Briefly the procedure of building the mould consists in sweeping two bearances from a vertical spindle. One forms a cup for the hub or boss, which is subsequently built up and swept to form a loam pattern, the other is used to locate the race or angle. When the hub pattern has been swept and the angle located and fixed in position, a balanced sweep is located on the vertical spindle, which rides on the angle, and by rotating it about the width of a blade its edge develops the working surface of the blade. It is only necessary to build up to this edge with bricks and loam to enable a loam surface to be swept, taking care that the area of the surface is adequate, not only for the shape of the blade but to provide a joint for a cover. This procedure is repeated for each blade, the angle being moved to its next position. The sweep for generating the blade surfaces generally carries a number of small projections which mark the surfaces at known distances from the centre of the hub; these marks are used for locating thickness pieces corresponding to the thickness of each blade at the predetermined positions. When each blade has been built up, the bottom part of the mould is formed and it can be moved into an oven to be baked.

After drying the bottom of the mould, the contour of each blade is required to be marked out, and invariably the pitch is checked. It should be mentioned that some foundrymen prefer to make the pitch at the tips of the blades slightly coarser than required, this is to allow for the drawing of the casting when cooling. With rod iron or strip wood forming the contour of the blade and thickness pieces located in their respective positions, a skeleton pattern is formed. Sand is rammed between and strickled off to represent the complete shape of a blade. The process is repeated for each blade, and when the rod iron or strip wood is removed the sand forming the edge of the blade is slightly rounded, but the edge is left thickened.

There is much diversity of opinion among foundrymen regarding the best form of cover to provide for a mould of this character. Covers for each blade are prepared separately, and different methods of reinforcing the loam are adopted. In addition to separate covers for each blade, a further joint must be made about the top of the hub, so that the shaft core can be located when the mould is assembled for casting. After baking the complete mould, the covers are lifted and the loam-and-sand pattern is removed, the mould surfaces being subsequently prepared for casting when the covers are replaced and the mould assembled. Although no reference has been made to arrangements for the entrance of the metal, it will be appreciated that gates and risers are prepared when

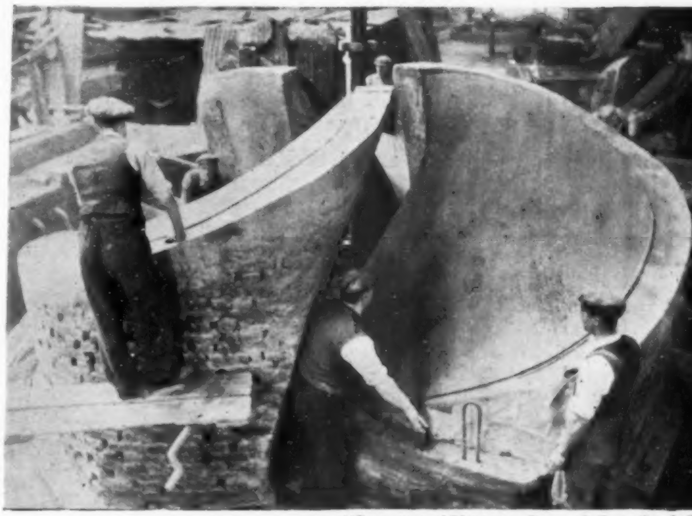
(By courtesy of J. Stone & Co., Ltd.)

Finished propeller for the Queen Mary. Probably the largest in the world; it weighs 35 tons.

building the mould. Methods differ with the metal to be cast, and in this respect the making of propellers does not differ from other types of castings.

Metals Used

In determining the metal of which a propeller is to be cast many factors are involved. It is a vital part of a modern ship and inferior material may involve the ship owners in considerable expense. The metal employed should offer considerable resistance to corrosion, possess high strength, and be easily cast. For many years the choice lay between cast iron, steel and gunmetal. The use of cast iron propellers still predominates, particularly for vessels in the merchant service; its relative cheapness combined with good resistance to corrosion are favourable to its use. Steel castings of this type are not common and gunmetal castings have been entirely excluded for propellers in view of the advantages possessed by several high-tensile brasses which have been developed. The original non-ferrous alloy used for this purpose was a true bronze, *i.e.*, a copper-tin alloy strengthened by the addition of suitable proportions of ferro-manganese, the constituents being completely alloyed, but after numerous experiments the late Mr. P. M. Parsons found that still better properties could be obtained by making similar additions to the copper-zinc alloys or brasses. These discoveries in 1876 led to the alloy known as "Manganese Bronze" and were the origin of the present series of high-tensile bronzes and brasses.



(By courtesy of Manganese Bronze & Brass Co., Ltd.)
Working on the lower half of the mould for one of Normandie's propellers.

In the early days the working conditions—that is, the speed and the power transmitted—were not so exacting as to-day, and a tensile strength of about 30 tons per sq. in., with good ductility and shock-resisting properties, coupled with immunity from sea-water corrosion, were readily obtained, whilst the added advantages of reduced weight, true pitch and the high finish all helped to give better efficiencies, increased speed, and lower fuel consumption than had been possible with ferrous materials.

The advent of the steam turbine, which led to such an advance in marine propulsion, had important repercussions in the propeller world. The faster running engines and increased power output available were immediately taken advantage of by those firms involved in the struggle for speed and its attendant supremacy, with the result that the propeller manufacturer was confronted with the effects of cavitation and other new problems. More recently there has been far-reaching advances in propeller design, arising out of the introduction of aerofoil blade section which depend for their success almost as much on accuracy of manufacture as on the attainment by the designer of ideally shaped blade sections. The last half century has seen continuous research and experimental work directed towards the improvement of the final product. As a result, to-day it is possible to obtain alloys with characteristics suited to every class of duty.

(By courtesy of Manganese Bronze & Brass Co., Ltd.)
One of Queen Mary's propellers in the mould with covers removed.

Manganese Bronze

The original brasses consisted of the well-known duplex alpha-beta structure, and whilst these had proved completely satisfactory for the conditions then existing, and the life of a propeller was equal to the life of the ship, the new conditions brought the problem of erosion very much to the fore.

As the result of an investigation on the "Erosion of High-speed Propellers," under the direction of the late Sir Charles Parsons, which has come to be regarded as classical, it was shown that water-hammer or cavitation due to the collapse of vacuum cavities, caused by the movement of the propeller was one of the prime causes of erosion. In the light of this knowledge prolonged research was undertaken, which led finally to the production of an alloy characterised by an all-beta structure, which was capable of resisting this erosion. For a long time the view had been maintained that an alloy consisting only of the beta structure would be too hard and brittle to have any commercial value, but the required degree of toughness and ductility was attained by suitable additions of nickel and a careful adjustment and control of the other added metals. This alloy has an ultimate strength of about 40 tons per sq. in., with an elongation of about 20%.

High tensile brasses of this character, which are now exclusively used for the propellers of vessels of the highest class, such as those required for passenger service and for Admiralty work are based on the 60/40 type of brass, the several added elements replacing in part the copper or the zinc. They are complex brasses having vastly different physical and mechanical properties from those of the straight brass. These added elements naturally exercise considerable influence over the casting properties of the metal, and, in addition to careful mixing, the alloy must be thoroughly studied to produce a successful casting.

The manufacture of these special brasses necessitates strict supervision of the composition as well as of melting conditions and the temperature of the furnace. Abnormal gassing, want of homogeneity in the mixing, undissolved portions of the alloying metals, high melting losses of one or other constituent, segregation and other troubles are likely to be encountered if the alloy is not properly prepared. Fortunately stock ingot metal can be purchased from a reputable manufacturer, and, with this metal in particular, is recommended. Manganese bronze, corrected for normal melting losses, to almost any specification within reason, together with information as to the best melting and casting temperatures for the parcel of ingot supplied, are readily obtainable from trade sources. Complex alloys of this charcater should be first prepared in ingot form.

Usually the constituent metals are first melted in crucible furnaces to effect the combination of high temperatures of the more refractory elements; the subsequent ingotting eliminating the gases absorbed during this process.

Melting and Casting

For propeller manufacture the second melting in bulk is usually effected in a large reverberatory furnace using a medium pressure draught. Rigid control is necessary throughout this operation in order to obtain the degree of superheat required to ensure perfect mixing, maximum fluidity and minimum oxidation, while avoiding any overheating of the material. In the case of propellers such as those for the *Normandie* or the *Queen Mary*, with a casting weight of about 35 tons and 50 tons, respectively, special precautions have to be taken to ensure that the metal in several furnaces required reaches its casting temperature at the same time, because the metal is not improved by being held in a fluid state.

When the metal is in suitable condition the furnaces are tapped and the molten metal transferred as rapidly as possible by ladles to the mould, a quantity of metal being left on top after the main cast is completed, to be added at intervals covering several hours, in order to counteract the contraction which takes place as the metal cools. The casting is then left to cool in its mould, the time may extend to a week according to the size of the propeller, when the mould is stripped and the machining processes carried out. After removal of the riser head the propeller is passed through the machine and trimming shops where the hub or boss is faced and bored, the key-ways cut, the blades trimmed to the required pitch and dimensions, ground and polished, and the propeller much reduced in weight is finally balanced.

Aircraft: Materials and Testing

The tenth Edgar Marburg Lecture at the recent annual meeting of the American Society for Testing Materials was delivered by Dr. L. B. Tuckerman, of the National Bureau of Standards, Washington, on the above subject. He described the relation between the mechanical properties of the material and the design of struts, beams, etc., and the craft as a whole, to produce light-weight construction, and stated that theoretical and experimental investigation all show that light-weight construction depends on spreading the material as far as possible out from the axis of the elements; hence we have thin-walled construction, that is, thin webs and flanges, thin-walled tubes, etc. The significant properties, density, strength density-ratio and modulus density-ratio of selected materials were compared. The comparison shows, that from these purely structural considerations, with the materials now available, there is little choice between the three types of construction now in use, wood, light aluminium alloys and high-strength alloy steels. The choice between them must be based on other considerations, ease of fabrication, resistance to deterioration by weathering, etc., and finally upon knowledge of the designs which will utilise best the possibilities of the material.

He indicated that no radical improvement in light-weight construction is at present to be expected from still further increasing the strength of the materials. There is, however, much room for improvement in the knowledge of the possibility of designing to utilise more fully the strength of materials now available. Systematic tests such as these offer present promise of materially improved light-weight construction. Tests of this kind are being carried out in many laboratories, but many more are needed if progress in light-weight construction is to be maintained.

Several important improvements over earlier models have been incorporated in the new Hilger quartz spectrographs, information on which is contained in a recent publication by Adam Hilger, Ltd., 98, Kings' Road, Camden Road, London, N.W. 1.

Forthcoming Meetings

Iron and Steel Institute

Autumn Meeting at Manchester

The Annual Autumn Meeting of the Iron and Steel Institute will be held in Manchester. The provisional programme issued indicates that the proceedings will begin in the evening of September 16. On the following morning the members assembled in the Hall of the Manchester College of Technology will be accorded a civic welcome by the Lord Mayor of Manchester, after which a technical session will be held.

In the morning of September 18, a general meeting will be held in the Students' Common Room at which papers will be read and discussed. Works visits are an important item in the programme, and arrangements have been made to visit the local works of many Companies on September 17 to 18, while on September 19, arrangements are made to visit works of the United Steel Companies, Ltd., and the Millom and Askam Hematite Iron Co., Ltd., on the Cumberland Coast. The programme also includes arrangements for a visit to the Lake District.

The Institute of Metals

Newcastle-upon-Tyne Conference

This year's Annual Autumn Meeting of the Institute of Metals will be held in Newcastle-upon-Tyne. The 27th gathering of the series, it will take place from September 9 to 12, under the chairmanship of Dr. Harold Moore, C.B.E., President of the Institute. In accordance with the programme issued, the proceedings will begin in the evening of September 9, with the delivery by Dr. H .W.Brownsdon of the 14th Autumn Lecture on "Metal Melting—Its Effect on Quality." The lecture will be discussed—a novelty on such an occasion.

On September 10, the assembled members will be given a civic welcome by the Lord Mayor of Newcastle-upon-Tyne before beginning the discussion of a series of technical papers relating to various phases of metallurgical work. In the afternoon parties will be formed to visit works of metallurgical and engineering interest, and in the evening a civic reception and dance will be given. On September 11, the morning will be devoted to the discussion of further papers, the afternoon to works' visits, and the evening to a dinner at the Royal Station Hotel. An all-day motor trip on September 12, to the Roman Wall and Fort at Borcovicus will conclude the conference.

Institute of Marine Engineers

On September 10, a paper will be given by Mr. H. G. Leivesley, entitled "Marine Electrical Installations in Service." The meeting will commence at 6 p.m. at the Institute, The Minories, London, E.C. 3, with Mr. T. R. Thomas, B.Sc., Chairman. For the convenience of members and visitors tea will be served in the Library from 5 p.m.

International Foundry Congress

The International Foundry Congress is to be held at Brussels on September 20—25, under the auspices of the Association Technique de Fonderie de Belgique. It is being held in co-operation with the activities associated with the Brussels Exhibition, which is claimed to be the most important world's fair since Paris, 1900. Thus, apart from the technical sessions, social functions and visits connected with the Congress, there is an additional incentive to visit the Exhibition. Those proposing to attend this congress should communicate their intentions without delay, to Mr. T. Makenson, St. John Street Chambers, Deansgate, Manchester 3.

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The Organisation of Industry

THE economic crisis experienced in this country in 1931 was the cause of many schemes designed to effect recovery in the shortest possible time. Many were sufficiently optimistic to believe that the adoption of this or that scheme would change conditions in such a short time that the need for alarm seemed absurd. On the other hand Mr. Chamberlain, as Chancellor of the Exchequer, expressed the view that recovery would occupy a decade. Between these extreme views much has been done by Government action to facilitate recovery of industry and commerce, of which the most important were the new monetary policy and the institution of protective tariffs. The gradually improving returns show that progress is being made, but it will be admitted that although the tendency of British trade has been and is in the right direction, the actual improvement registered does not warrant any feeling of complacency. Too great a proportion of her revival in industrial activity has been due to the demands of the home market; too little has been due to a real development of the export trade, which is vital to the future prosperity of this country.

Taken as a whole, the policy adopted by the Government has secured a remarkable degree of economic recovery for this country, as compared with that of other countries during the same period. In the home market the consumption of domestically-produced goods has substantially increased; in the Empire market United Kingdom exports have advanced, both in value and as a percentage of her total exports; with the Trade Agreement countries, British exports have also gained ground. There is, however, a tendency to assume that the impetus given to recovery will cause trade to grow with snowball speed in a relatively short time, but the policy will need considerable extension to achieve the success so desirable.

It has already been observed that real development of the export trade is vital to the future prosperity of the United Kingdom. How is this recovery, which essentially depends upon stimulating the growth of international trade as a whole, to be brought about? A special Committee, appointed by the Grand Council of the Federation of British Industries to report upon the principles underlying the various schemes for industrial reorganisation, state that the remedy usually advocated is to reduce "trade barriers," and to endeavour to achieve a stabilisation of exchanges. Trade barriers and unstable exchanges are not, it is stated, the basic cause of world depression. They are a symptom, and the result of unsound economic policy, both national and international, on the part of the countries of the world. To-day, the industrial countries are devoting their attention towards stimulating their agriculture, often without any regard to the economic possibilities involved. Agricultural countries are similarly embarking upon industrial production, irrespective of its economic justification. Unless this policy is kept within reasonable limits, there would appear to be little likelihood of building a firm foundation for a resumption of international trade on a large scale, which depends in essence upon the exchange of manufactured goods for agricultural produce and raw materials.

It will be admittted that a fuller and more complete organisation is required for the solution of the problems which are acute in industry to-day. Circumstances vary from industry to industry, and many of these problems are more noticeable in the older established than in the newer industries, which are still in process of development. Several industries have already advanced a considerable way in dealing with these problems on a basis of co-operation. Mention may be made of the shipbuilding and woolcombing industries as cases where schemes are in working operation for regulating the production capacity of the industry to existing consumptive demand, which the new constitution of the British Iron and Steel Federation permits of the central control of every phase of activity in one of the greatest staple industries of the country. But there is ample room for more intense organisation of industry, since the work already accomplished has only touched the fringe of the problems. That it has had little or no influence on the depressed areas is indicated by the admirable gesture of Mr. L. D. Whitehead, of the Whitehead Iron and Steel Co., Ltd., who offers a substantial money prize for the most practical suggestions for permanently reducing unemployment in South Wales. Responsible people in other areas that continue to suffer heavily from the depression are not less anxious for practical suggestions suitable for their own districts.

There are no end to suggestions of a kind, but the great majority amount in the main to vague generalities and pious hopes, which, when carefully considered, have little practical application to the needs of industry or the community. An admirable exception to this is contained in a book recently published by Macmillan and Co., Ltd., entitled "The Next Five Years." It is in two parts, dealing respectively with economic policy and with peace. The general policy proposed in this book embodies a far-reaching programme of action for the next five years. It is agreed upon by 151 signatories, who are representative of different parties and schools of thought.

The economic section of this book opens with a strong plea for the right sort of planning. Planning it argues need not mean a vast increase in the interference of the Government with the liberties of the people. It means only that all the various sections of the Government policy should be consistently fitted together. To do this the book recommends an Economic General Staff similar to the Committee of Imperial Defence which co-ordinates the policy of the fighting forces.

In the chapter dealing with the Organisation of Industry the book breaks new ground and, to all interested in the prosperity of this country and its people, we commend its thoughtful presentation of a working policy. It states that no one method is applicable to the needs of every industry, and five different methods are suggested. For general application the passing of an Enabling Act is recommended. This Act should set up an Industrial Advisory Committee, on the lines of the Import Duties Advisory Committee, to examine and pass schemes submitted by industries. Schemes, when approved by the Committee and by the President of the Board of Trade and laid before Parliament and the public, should come into force by Departmental Order. Four broad types of organisation are envisaged to meet the circumstances of those industries which for one reason or another need a degree of organisation or of public control which they would not achieve for themselves under the Enabling Act. The signatories believe that this book embodies a far-reaching but attainable programme of action for the next five years. We can say with justice that it is one of the few that show distinct promise of practical application.

Rear Axle Gears:

Factors which Influence their Life

As the result of a study of the factors which influence the life of rear-axle gears, it is claimed that there is no evidence of one alloy, among the alloys generally used for this purpose, being superior to another. The investigation is summarised in this article.

DURING the last few years the General Motors Research Laboratory has run breakdown tests on some four hundred rear axle assemblies. The data obtained from so large a number of tests offered unusual opportunities for the study of actual machine elements as fatigue specimens in comparison with fatigue data from many sources on standard laboratory specimens. The results of these investigations, given in a paper by Messrs. J. O. Almen and A. L. Boegehold at the recent annual meeting of the American Society of Testing Materials, indicate that the factors which influence the life of rear axle gears are not in accord with those at present recognised Of particular importance was the fact that fatigue tests on complete rear axle assemblies could be related to the actual service of these axles in the hands of many thousands of automobile owners through the service records maintained by the manufacturing divisions.

The authors show that it is tenable to consider the gear tooth as a fatigue test specimen simulating an ordinary intermittently loaded cantilever beam with full tangential load carried on one tooth. As a result, many observations that have long puzzled engineers and metallurgists are found to fit in an orderly and rational manner with fundamental knowledge of design and materials. It is further shown that axle gear failure in service is due to fatigue failure of the gear teeth under maximum low gear torque. Using this loading condition, the laboratory fatigue tests of axle assembly rate the gears in the same order as in service. Due to their influence on stress concentration, variations in design and manufacturing have a materially greater effect on gear life than do variations in materials and heat-treatment. The effect of metallurgical change is obscured by the effect of these stress concentration factors, which include (1) elastic deflection of teeth, shafts and bearings, (2) surface cuts and scratches, (3) tooth shapes having abrupt change of section, (4) eccentric assemblies, (5) heat-treatment distortion and incipient quenching and grinding cracks, and (6) non-uniform load distribution along the tooth.

It is suggested that to obtain improvement in gear life the engineer should first look to improvement in design and manufacturing before resorting to metallurgical change.

At one time it was generally believed that axle gear-tooth failure in service was due to shock-impact loading. In consequence, tests and materials specifications were in accordance with this theory of failure, which led the investigator astray. Also, it was at one time suggested that axle gears might be overloaded due to impact loading under high-speed operation. This speculation in the case of axle gears was based on the general theory suggested by Buckingham[1] that gears in some types of high-speed service are subjected to high-impact loads due to oscillation of the gears, and that gear fatigue failure is often due to the overstress resulting from such shock loads rather than to the normal driving loads.

To determine whether such impact loads were contributing to automobile rear axle failures, measurements were made of the elastic characteristics of the rear axle structure from the front end of the propeller shaft to the road tyres. It was found that the elasticity in this driving train relative to the moment of inertia of the gears is such as to make impact loading of the type described by Buckingham practically impossible in automobile rear axle gears. The authors show that gear-tooth failures may be plotted on the familiar S–N curve when the gear stresses are properly calculated. They emphasise that the Lewis formula, widely used for calculating gear-tooth stress, leads to serious errors.

The conclusions resulting from these investigations undermine preconceived ideas. The authors assert, for instance, that the impact theory of tooth failure in axle gears has led to erroneous conclusions with regard to relative strength requirements of case and core. In consequence, laboratory tests designed to aid in evaluating materials have led the investigator astray, since these tests were responsible for the widely held belief that any carburized gear tooth should have a hard case and a tough core. The fatigue theory of failure alters the conception of case and core requirements. For many years it was customary to test automobile gears in various impact machines. The designer of this type of test assumed that gear teeth in service were subjected to hammer-like blows, and he therefore attempted to duplicate in the laboratory this type of load. Under this test the best material was that which resisted the greatest number of blows notwithstanding the fact that the gear was usually ruined after the first impact. Hence, the specification that carburised gears must be of such materials and heat treatment as would produce a hard surface to resist wear and a tough core to resist breakage by impact.

When it is realised that rear axle gear teeth are not subject to hammer-like blows, the tough core requirement vanishes. As an intermittently loaded beam, the tooth surface must not only resist wear but, since the bending stress varies from a maximum at the surface to zero near the tooth centre, it becomes important to provide a surface highly resistant to fatigue in bending with less fatigue resistance required of the core depending upon the depth of carburisation. Although the data given on this point are rather meagre to be conclusive they indicate that resistance to fatigue is perhaps improved with reasonable increase in depth of carburisation.

Probably the most contentious part of this paper is that which concerns the material and heat-treatment. There is, for instance, no evidence from the present study to show that, among the alloys generally used for this purpose, one is superior to another. Tests of 250 axles made from 22 combinations of alloys and heat-treatments are recorded, and it is shown that, regardless of material, heat-treatment or grain size, the test points for any given material lie about equally divided above and below the average curve.

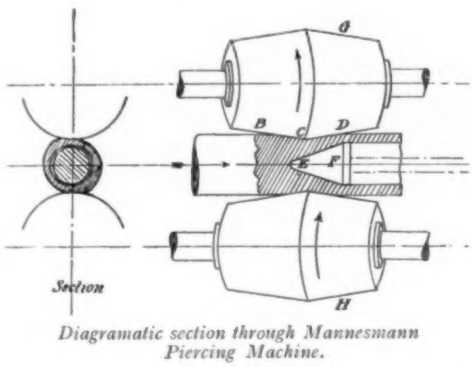
The authors do not deny that there are real differences in the various alloys or in the effects of the various heat-treatments. These differences, however, have been determined from rather ideal laboratory tests, under which conditions such differences are relatively large enough to become appreciable. In highly finished uniform-section structures, such as ball and roller bearings, wrist pins, ground shafts, and the like, the superior properties of expensive alloy steels are usually realised. In structures having high stress concentration, such as production rear axle gears, the properties of alloy steels, as determined by the usual laboratory tests, are not realised. The selection of steel for rear axle gears should be governed by warping tendencies, machining characteristics and cost.

SEAMLESS TUBE MANUFACTURE

By GILBERT EVANS

There is little that it is not possible to produce direct from the solid ferrous or non-ferrous billet and in view of the developments in the manufacture of seamless tube the author asks: "Has the last word been said?" In this article he reviews the more important developments which are responsible for the evolution in manufacture.

THE remarks of the managing director of one of the largest tube manufacturing works in Great Britain intrigued the writer in a recent interview. They were to this effect. "We tube makers are of the opinion from week to week that at last the perfect combination of piercing, rolling, and drawing has been obtained and in the next few days, you inventors come along with a new practical design. Evolving from the original Mannesmann rotary piercing machine has come the Stiefel Disc Mill; the Evans mill, now the Diescher Reducing process and last of all the Foren mill all of which are in operation in Great Britain, America, Germany and Sweden. All these inventions leave us in a maze, and so great is competition that the manufacturers of tubes, ferrous and non-ferrous, hesitate which process is of the greatest commercial value."



Diagramatic section through Mannesmann Piercing Machine.

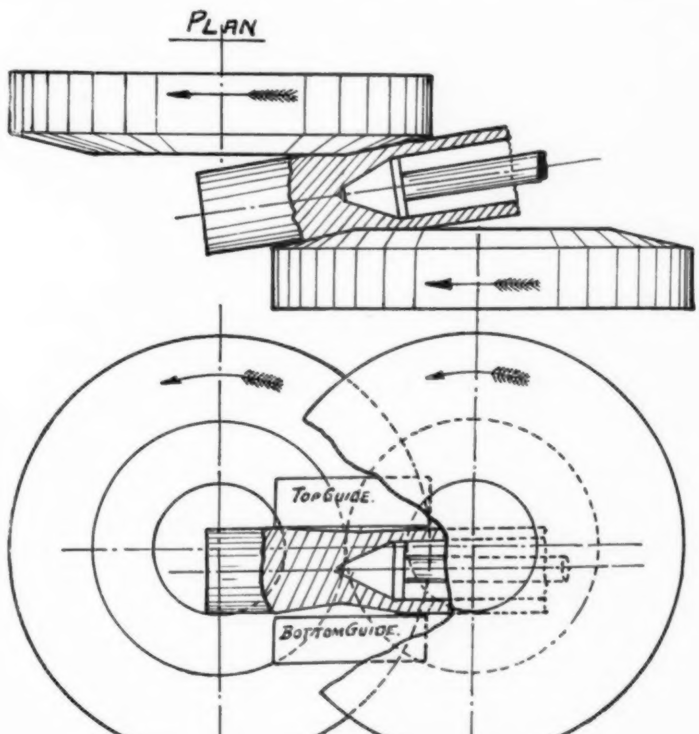
As a result of long experience as works' manager, engineer and consultant, respectively, to the Mannesmann Tube Co., Ltd., of Landore, Swansea; Tubes Ltd., Aston, Birmingham; The Yorkshire Copper Works, Ltd., Leeds: Ansaldo of Genoa: Finspong Metallverke A/G, Sweden: and Porsgrand Metallwerkes, Norway, the writer considers there is little that it is not possible to produce direct from the solid steel or non-ferrous billet at one heat. To-day tubes of all diameters down to ⅜ in. × 16 I.W.G. are being produced. It is interesting to study the evolution in manufacture effected during a relatively short time, and in this article it is proposed to review briefly some of the important developments.

Mannesmann Rotary Piercing Machine

In 1886 the German Mannesmann Tube Co., Ltd., of Komataw, Remscheid and Dusseldorf, purchased the two works of the Landore Siemens Steel Co., Ltd., to the latter of whom the writer was indentured as an engineering apprentice. At the end of 1887 operations were commenced under the direction of Engineer Julius Pfau, a Swiss. It is generally recognised that the Mannesmann family were the pioneers of the seamless steel-tube trade, and were the originators of the rotary piercing machine. The introduction of this rotary process caused a revolution in the tube trade, superseding as it did the old-fashioned methods of boring a solid billet—with a waste of 30% of the metal and subsequent laborious rolling on to a plug in band rolls with gradually decreasing groves of varying diameter.

Stiefel Disc Rotary Piercing Machine

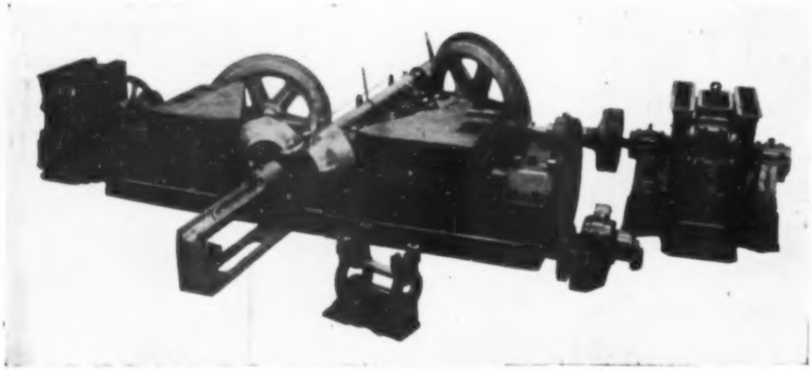
About 1890 came one Ralph Carl Stiefel of Swiss descent who occupied the post of Chief Draughtsman, under the control of Julius Pfau works manager and engineer. In the year 1896 the first names conceived the idea of his now famous disc (Tandem) rotary piercing machine, on the design of which the author worked in his private time. Stiefel chanced his luck and emigrated to Ellwood City,



Side elevation of Stiefel's patent with part disc removed.

Pa., U.S.A. in 1898, the writer succeeding him as work's manager and engineer at Landore. His invention was immediately taken up in America by the Steel Tube Corporation, and the export from Great Britain of 200 to 300 tons per week of hollow blooms for the manufacture of boiler, stems and cycle tubes received a very considerable check. There is little doubt that R. C. Stiefel was the pioneer of the seamless tube trade development in U.S.A. His application for patent rights in Germany and Great Britain was contested by the Mannesmann's and after costly litigation in both countries, his claims were established.

In 1900 the sole rights for Great Britain were invested



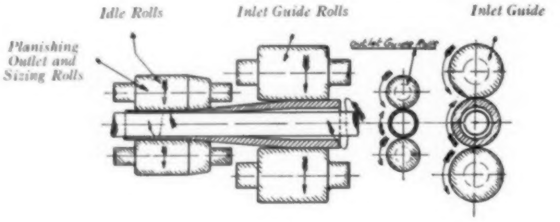
Evans' Rotary Piercing Machine. Although piercing by hydraulic pressure is still used, the introduction of the rotary piercing machine is being increasingly adopted.

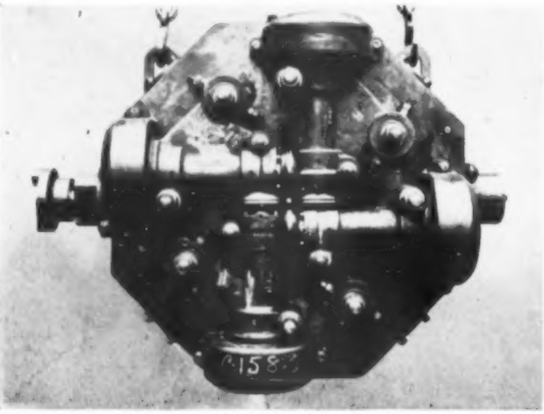
$\frac{3}{8}$ in. thickness from solid billets of $1\frac{1}{4}$ in. up to $6\frac{7}{8}$ in. diameter, the largest size being obtained by a secondary expanding.

Evans' Rotary Piercing Machine.

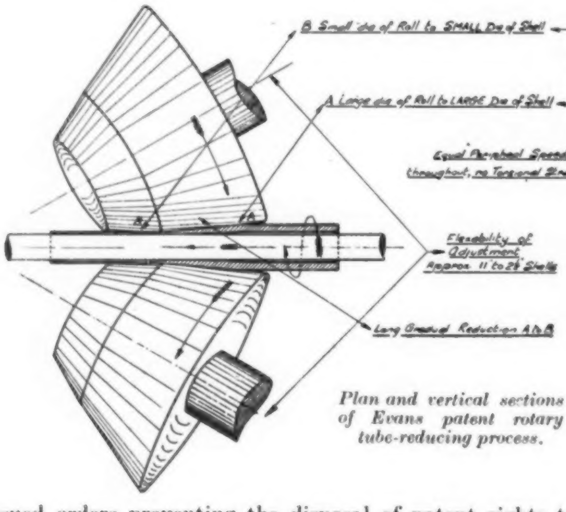
During 1914—at the outbreak of war—the writer concluded his contract with The Yorkshire Copper Works in order to exploit his ideas in rotary piercing, and his first rotary mill was erected at The Birmingham Battery and Metal Co., Ltd., Selly Oak, Birmingham. So serious was the situation for the supply of non-ferrous tubes for purposes of boiler tubes, driving bands, etc., that the Admiralty issued orders preventing the disposal of patent rights to the Battery Co., and orders were placed for mills to be installed at earliest moment at Muntz Metal Co., Ltd., and Allen Everitts and Sons, both leading firms in Birmingham. These were erected and developed in 1916. Swedish manufacturers of tubes were later interested, and in 1928 the largest Evans mill was erected at The Finspong Metallverke A/G with a flexibility from $1\frac{5}{8}$ in. up to—by expanding—20 in. diameters. Meanwhile slightly smaller mills had been supplied to the Japanese, and to Metal Manufacturers, Port Kemble, New South Wales.

in Tubes Limited, Aston, Birmingham, and were developed under the supervision of the writer who remained in charge until 1908. Then came the further invention of the Mannesmann brothers, Carl and Reinhard—The Pilger or Step by Step process—which displaced the old methods of rolling on to and off the plug, an invention of W. and A. Pilkington, of the Star Tube Works, Heneage Street, Aston, and later of the Climax and Credlenda Tube Works, of Aston and Smethwick respectively. Further developments followed, and in 1908 the writer left the ferrous tube trade to study the non-ferrous trade, with the result that Stiefel's new rotary was erected and developed by the then Leeds—now the Yorkshire Copper Works. Ltd. On this mill it was possible to manufacture tubes of from $1\frac{1}{4}$ in diameter $\times$ $\frac{1}{8}$ in. wall thickness to any desired diameter up to 10 in. $\times$

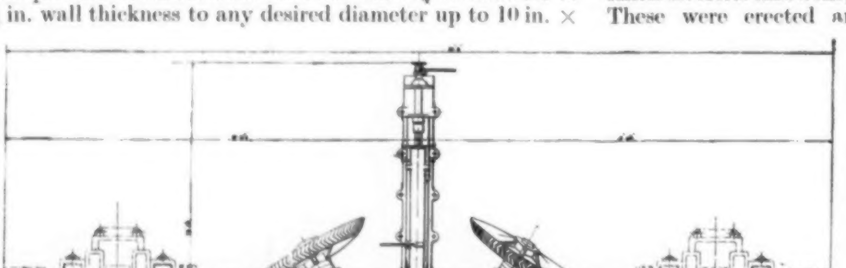




Quarto tube reducing machine.



Plan and vertical sections of Evans patent rotary tube-reducing process.



General arrangement of rotary piercing machine. Evans' patent.

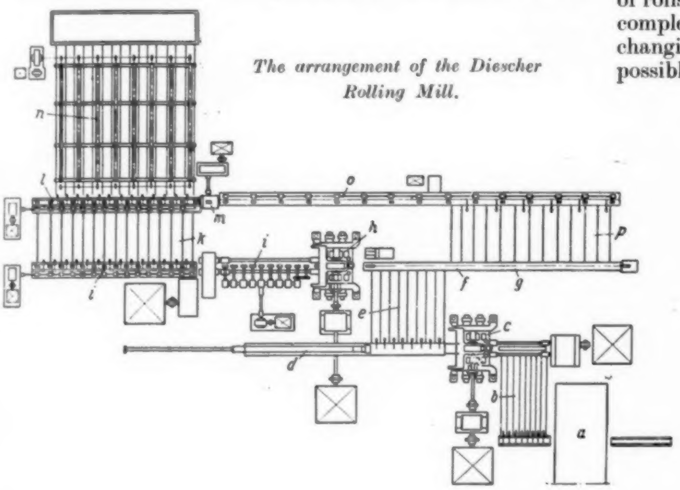
Push Bench Process.

Leaving for the moment the rotary mills, we come to the Push Bench Process, a combination of the vertical hydraulic press, and the horizontal draw bench, which is adaptable for steel or alloys, and which is a development of the famous Robertson, St. Helens, Lancashire process. This installa-

tion, built by the Wellman Seaver Co., of U.S.A. and Darlaston, England, has been supplied to leading firms in Great Britain, U.S.A. Germany and Canada. It is not within the writer's province to minutely criticise this process under review, but its efficiency has undoubtedly been proved, especially in regard to treatment of stainless steel, a quality of material not yet entirely amenable to the torsional stresses set up in rotary piercing. Speeds of 800 ft. per minute were obtained, with somewhat excessive wear and tear on mandrels and dies, manufacturing drawbacks recently considerably reduced, making the invention of real commercial value.

Diescher and Foren Tube Mills.

Since 1931, and as recently as 1933, two entirely new combinations have been patented in all countries in the Diescher and Foren, by which it is possible to produce at one heat from the solid billet, tubes of any diameter down to ⅜ in. × 14 I.W.G. the sole patent rights of which are invested in the



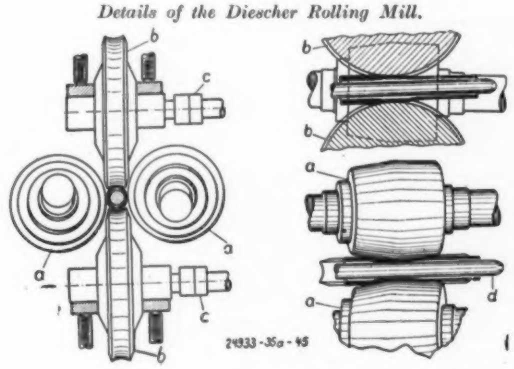
The arrangement of the Diescher Rolling Mill.

largest ferrous and non-ferrous tube manufacturers in Great Britain. The first named is an adaption of the Mannesmann piercing process by which the hollow shell direct from the initial piercing process is passed through a mill, the rolls of which are inclined to the horizontal working centre at an angle of 5 to 6°, and wall thickness, the length of the finished article being, of course, dependent on the weight of the original solid billet.

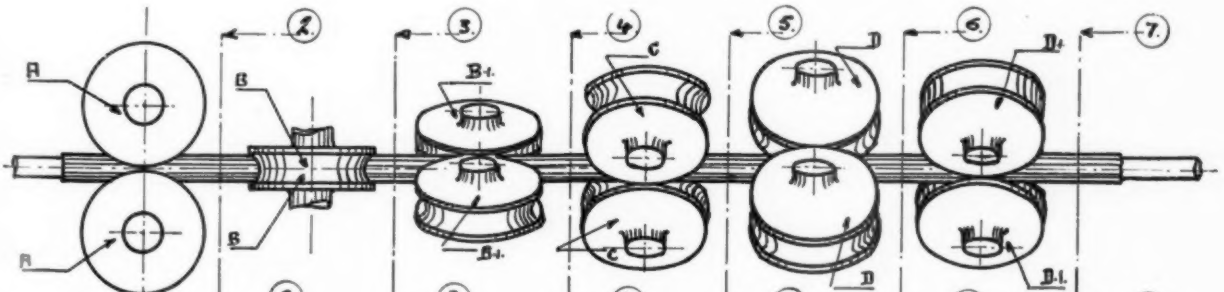
In the design of the cross rolls, the finishing planes of the rolls are parallel, which imparts to the tube under operation a planishing action, entirely removing such defects as waviness, scratches, etc., which develop in the initial piercing. To accelerate the passage of the hollow steel through the Diescher mill, a series of high speed discs are operated between the working rolls, which also serve the purpose of releasing the finished tube from the internal solid mandrel, and makes the extraction of the mandrel from the finished tube an easy matter. As the limits of sizes in *hot*-finished tubes are so elastic, both in regard to diameters and wall thickness the possibilities of the Diescher mill are obvious Yet the cost of upkeep on the working rolls, owing to extreme wear and tear, must be considerable.

To a keen student of piercing and rolling the term "kneading," which is so prominent in the claims of the Foren invention must appeal as does "cogging and breaking down" on the process of steel and non-ferrous alloy manufacture. In place of the generally accepted alternative horizontal and vertical grooved rolls, the Foren process embodies a series of rolls set at angles of 22·5°, each of which set of rolls operate on 45% instead of 90% of the material being treated. Thus, by means of a set of say 6 rolls revolving at a forward speed of 17 ft. 0 in. per sec., or 1,020 ft. per min., each section of the tube is kneaded on to the interior mandrel, finally passing through a pair of rolls which restores complete circularity and atthe same completely releases the tube from the interior mandrel. By changing the diameter of the said interior mandrel, it is possible to obtain tubes of varying thicknesses, and by a

Details of the Diescher Rolling Mill.



series of Foren mills, or, by using subsequent reducing and wall thicknesses. Both the Diescher and Foren mills are a direct challenge to extrusion methods, which have so greatly developed in the past few years, especially in the non-ferrous tube trade, and by extrusion and reducing, the costly heat treatment and pickling has been reduced to a minimum, where specifications call for small limits in the cold-drawn article. As an example: in the manufacture of such tubes as are required for locomotive and condenser mills to produce tubes of any desired smaller diameters tubes where six or seven cold passes—with attendant annealing and pickling treatment between each cold pass—it is now possible to manufacture with at the most two cold passes, and only one annealing and pickling, thus removing the most costly item in the manufacture of tubes.



Side elevation showing the principle of P. A. Forens Rolling for tubes.

METAL CUTTING

A very careful and instructive study of chip flow in metal cutting is summarised in this article. It is shown that a well-defined distribution of stress is produced, when cutting, and that a zone of highly worked material will develop into a shape similar to the cutting tool.

IN all studies of chip flow, state Messrs. Hans Ernst and M. Martellotti,* one of the most outstanding facts observed is that there exists, under certain conditions, a relatively stationary wedge-shaped bodv of material which precedes the nose of the cutting tool, and appears to cling thereto, while the main body oi the chip flows over it. The existence of this phenomenon has long been known, but only in recent years has any considerable attention been given to a study of its occurrence, and to the profound influence which it exerts both on the quality of surface produced on the work and the wear on the cutting tool. Investigations by a number of workers have shown the existence and change of form of the wedge-shaped structure with various materials, depths, and cutting speeds and with various angles of the cutting tool; nevertheless, there is still a great deal of misunderstanding in regard to its formation and the factors which promote or retard its development.

Even among those who have studied it closely there are fundamental differences of opinion as to how it is formed. Some have asserted that it is composed of an aggregation of small particles, scraped from the work surface by the extreme edge of the took, which form themselves into a solid mass wedged between the tool and the chip. Others have stated that it is formed by the welding together of successive layers of metal, each in turn being formed of material dragged back by friction from the flowing chip and consolidated into a hard layer. Even the name which is generally adopted for this phenomenon—*viz.*," built-up edge," indicates the absence of a clear understanding of its formation, being indeed a relic of the early conception of an accumulation of particles; while the term adopted by other workers either do not suggest the true importance, or properly indicate its formation and function. However, until some more appropriate name is suggested, and in view of the wide use both in England and America of the common term "built-up edge," the authors consider it wiser to continue to use it.

The practical importance of a study of the formation of the built-up edge arises from the fact that its existence and magnitude greatly influence the quality of surface produced on the work and the mode of wear of the cutting tool. Accordingly, if a clear understanding of its formation can be obtained, we shall be better able to modify the design of the cutting tool, or the conditions of the cut, so as to obtain its advantages, or obviate its disadvantages, as the case may require.

The authors present a very careful and informative study of the subject, and conclude that in every metal-removing process the cutting tool induces high stresses, and consequent large deformations, upon the material which will finally form what is generally known as a chip. In this analysis it is shown that, in this process, a well-defined distribution of stress is produced, and that a zone of highly worked material will develop into a shape which is similar to that of a cutting tool. This is known as the built-up edge. The contour ot this built-up edge is determined by various factors, the principal one being the distribution of stress produced by contact between tool and work.

It is definitely shown that the built-up edge is not an accumulation of particles of material gathered by the tool as it passes over the work but on the contrary is composed of the same material as the chip, and its formation begins immediately the took comes in contact with the work. In many cases, however, it may not be carried to completion in the form in which we are accustomed to see it. This condition is well exemplified in the segmental-chip formation characteristic of relatively brittle work materials.

In cases where there is no apparent discontinuity of flow, as in the so-called "flow" type of chip, the built-up edge adheres to the face of the tool, and by virtue of its location assumes the function of cutting, thus relegating the function of the tool to that of cutter support. Any discontinuity which may appear in the formation of the chip will affect the life of the built-up edge, but it will form again as soon as the discontinuity disappears.

The following factors act to decrease the magnitude of the built-up edge :—

(1) A decrease in chip thickness.

(2) An increase in rake angle.

(3) An increase in tool sharpness.

(4) Application of lubricant to the tool face.

(5) Increase in cutting speed.

In heavy roughing cuts the built-up edge provides a protection for the extreme edge of the cutting tool, thus distributing the chip load over a greater area. On the other hand the existence of a large built-up edge permits the frequent escape of portions thereof underneath the cutting edge, thus producing a considerable erosion of this surface.

With a large built-up edge, the finished surface of the work presents a rough and torn appearance. This is because the continuity of the work surface is broken at frequent intervals by fragments torn from the built-up edge. Hence for production of the highest possible quality of finish, all conditions should be such as to reduce the magnitude of the built-up edge as much as possible.

The analysis of chip flow and formation of the built-up edge developed in this paper is presented as an introduction only. It is believed that the methods applied can be extended so as to lead to a proper evaluation of the variables encountered in metal cutting by studying their effects on the distriution of forces in the region of plastic flow in the neighbourhood of the cutting edge. Photo-elastic studies must be made to determine the exact changes in the shape of the stress-trajectory network with various tool angles; also with changes of contact area and depth of cut. This will permit the determination of the type of chip flow in accordance with the values of the various factors involved, and may lead eventurally to the formulation of a mathematical theory of metal cutting.

By anlysing the stress distribution produced by a tool on the work material and investigating further the process of plastic deformation and rupture, the authors believe it will be possible to bring into the realm of accurate analysis and control those factors which have been, and still are, so elusive in any cutting problem.

*Mech. Eng. Vol. 57, No. 8, pp. 487-498.

The Mines Branch of the Dominion Department of Mines at Ottawa has just issued Report No. 759, dealing with Petroleum Fuels in Canada—Deliveries for consumption during the calendar year, 1933. The report shows that there were marketed in the Dominion in 1933 a total of 945,000,000 Imperial gallons of petroleum products. The total included 56,000,000 gallons of fuel consumed in refineries, in addition to 419,000,000 gallons of fuel oil, 42,000,000 gallons of kerosene and 484,000,000 gallons of gasoline, whilst over 82,000 short tons of petroleum were marketed for fuel or consumption in refineries.

Marine Corrosion

By J. W. DONALDSON, D.Sc.

At the present time, engineers are confronted with many problems, but perhaps one of the most difficult is to ensure the life of any structures subjected to the action of sea water. This is particularly difficult in the case of metals where the forces tending to destruction may be of a chemical, physical, or biological nature. The only way to solve such a problem is by the accumulation of data, either by experience or by investigations, relating to the subject, and much work has been carried out during recent years. In this article the author reviews the subject.

FOR general consideration marine corrosion problems may be sub-divided into two groups, those connected with corrosion in the hulls of ships, as experienced by shipbuilders and shipowners, and those corrosion problems associated with iron and steel structures other than in shipbuilding.

Since the days of the first iron ships, sea water is the most corrosive agent with which the shipbuilder has had to contend. A very large proportion of the hull of a vessel is immersed in sea water and is consequently liable to be attacked. Serious general corrosion of hulls is rare, however, due to the fact that such structures are protected by painting at more or less regular intervals of time. Severe corrosive conditions may occur astern, resulting from galvanic action between the steel hull and bronze propellers, and in order to prevent such corrosion, zinc plates are usually attached to the stern plates of a ship. Such a method of protection has been criticised by certain authorities, who consider that such plates may accelerate corrosion by becoming cathodic to the steel by the deposition on them of carbonates and hydrates of zinc, and ships have been built in Germany which have not been fitted with such plates.

In recent years a number of cases of fairly rapid corrosion have occurred in vessels a few months after their construction, and have given rise to a considerable amount of trouble and anxiety to shipbuilders and shipowners, not only in this country but also on the Continent and in the United States. The corrosion which has occurred has either been in the pitting of the shell plates forming the hull or in the corrosion and pitting of the rivets, or both the plates and the rivets have been attacked. Where the plates have been attacked the corrosion has usually been found to be in the vicinity of the rivets, but there have also been many cases of attack at places quite remote from the rivets. Corrosion in tankers has also raised a very difficult problem, particularly in oil tanks carrying alternate cargoes of light petroleum distillates and sea water as ballast, and have rendered necessary considerable repairs in comparatively short periods.

These abnormal cases of corrosion have led to much discussion and many investigations have been initiated to determine their cause and prevention. Such work has either been carried out by private enterprise, or has formed part of the work of various research bodies, and much interesting and valuable information has already been obtained and published, although such investigations are necessarily of a prolonged nature.

Reports on Corrosion of Iron and Steel

In 1928 the Iron and Steel Institute and the National Federation of Iron and Steel Manufacturers appointed a Committee to investigate corrosion in iron and steel, and three reports have been issued by this Committee. In the first report published in 1931, a section was devoted to a critical discussion of the replies received from various shipping companies in answer to a questionnaire issued by the Committee. Information was asked for regarding the period of life of plates, sections, or sheets under different service conditions; if resistance to corrosion was affected by small differences in the composition of steel, by the method of steel manufacture, by the conditions of rolling, or by various methods of annealing; and if the addition of copper to steel increased its resistance to corrosion.

The replies received indicated that in general the ordinary steels of commerce gave satisfactory results for marine purposes provided that the necessary maintenance was efficiently conducted. Opinions varied as to the relative merits of iron or steel for shipbuilding purposes, or as to whether acid or basic steel was most suitable. No information was obtained regarding the use of copper content steel. In the discussion of this report, specific cases of corrosion were referred to and opinions expressed as to their cause. Expression was also given to the opinion that corrosion of ships' hulls is a more serious problem at the present time than twenty years ago.

In the second report of the Committee issued last year, a section was devoted to marine corrosion with particular reference to ships' hulls. In this section, consideration was given to the examination of ships for corrosion. In some of the cases considered, examination had been carried out by members of the Committee, and in others the information had been given by shipowners. Information submitted to the Committee was also considered, and includes the use of wrought iron in ship construction; some interesting cases of corrosion, which had been reported; the procedure followed in the painting of ships as practised by leading shipping firms; the effect of rolling scale, and the corrosion of rivets.

The Committee also stated that they had under consideration an extensive experimental programme of research designed to elucidate many of the problems dealt with in the two reports. It was suggested that such research should include an investigation into the nature of the steel-making process used for the manufacture of the various types of hull steels, whether acid or basic. The whole question of the properties of the rolling scale and its removal, either by weathering, pickling, or other means, had also to be considered, since serious corrosion can occur if the scale flakes off after painting and bare patches of the steel are exposed to the action of sea water. Tests would, therefore, have to be carried out on painted plates, weathered under different conditions for varying periods, and on plates descaled by pickling or by mechanical processes such as sand-blasting. It was also considered that tests on rivets of various materials and also on welded plates would be of value.

The Committee also consider that an investigation on the lines suggested should be supplemented by and correlated with parallel investigations on full sized ships' plates under service conditions. In co-operation with steelmakers, shipbuilders and shipowners, a series of observations have therefore been commenced on a number of vessels constructed and under construction. The complete history of shell plates from the steel-making process onwards is followed and such plates are inspected from time to time. Some of these cases are given in the second report, as well as the tests on the plates of a steel barge built under the Committee's observation. A complete record is given of the manufacture of the plates and of variations in the conditions of rolling of the various plates, and of their treatment, whether by weathering or descaling prior to erection and initial painting.

In the third report issued this year, the progress of the tests on the steel plates built into this barge are described by Hudson and Myers. It is stated that plates finished at a reduced rolling temperature, as a result of discontinuous rolling, shed their scale in the shipyard rather more rapidly than plates rolled under normal conditions. Inspection of the barge after being in service showed that any corrosion which had occurred had been initiated by mechanical damage, which rendered it difficult to compare the merits of the plates prepared in different surface conditions prior to the initial painting. Plates painted while not on the mill floor were in better condition than the others, when the finishing coat applied at the yard was bituminous paint, but in cases where the finishing coat was red oxide paint, the whole paint film tended to peel off the plate in a curious and unexpected manner.

Tests on welded specimens of ships' plates, both of ordinary and of high tensile " D " quality steel, conducted by the Admiralty after being exposed to various types of marine conditions for 30 months, are also dealt with in this report. The conclusion reached from these tests is that, on the whole, corrosion troubles should not be aggravated by welding, provided that the process is correctly carried out.

In a recent paper to the Institution of Naval Architects, the work of the Corrosion Committee as it affected marine corrosion is reviewed by Hatfield, who considers that the effectiveness of the paint is largely affected by the condition of the surface of the plates at the time of painting and that considerable attention can be given with advantage to the effect of the amount of scale, its nature, and also to the effect of freedom from scale. Scale may be removed by pickling or by sandblasting, but the cost of such practice is prohibitive for merchant shipbuilding, and the oiling of plates while hot to make them retain their paint more effectively is also expensive. Additional cost would also be incurred by modifying rolling temperatures to produce a scale which would quickly weather, owing to the output of the mill being affected.

In general, it may be concluded from the reports of the Corrosion Committee already published, from discussions on these reports, and from work carried out by other investigators that in order to obtain the best results from steel used in shipbuilding, it is necessary to submit ship plates to prolonged weathering to remove completely the mill scale which, owing to changes in steel-works practice, appears to be more adherent than formerly. Where time does not permit of such weathering, descaling should be carried out by some efficient method such as scratch-brushing, pickling, or sand-blasting. It is only when the steel is completely descaled, cleaned, and dried, that a protective coating of good paint should be applied. Repainting should only be carried out after all loose paint and rust has been removed.

Iron and Steel Structures

Work on the deterioration of metals, timber and concrete in sea water has been carried out since 1916 under the supervision of a Committee of the Institution of Civil Engineers. The progress of this work has been published in a series of reports by the Department of Scientific and Industrial Research, and with the publication recently of the 14th (interim) report it is possible to review the whole of the data accumulated after ten years tests and to draw certain conclusions from them.

The ferrous materials included in the tests, were wrought iron, ingot iron, cast iron, mild and medium carbon steels, copper steels, chromium steel, and nickel steels. These were exposed to conditions of aerial, alternating immersion, and complete immersion attack by being placed well above high water level, at half tide level, and well below lowwater level for periods of 5 and 10 years, respectively, at four test stations situated at Auckland, Colombo, Halifax, and Plymouth. Some of the tests were carried out on painted and others on unpainted specimens, and some of the materials were descaled before exposure. Most of the alloys were tested in their cast or rolled condition. The observation made included the loss in weight and the amount and character of the pitting in each specimen.

The tests on the various materials are being continued for a further period of five years, but meanwhile it is possible to form one or two important conclusions from the results published. A 36% nickel steel is most resistant to aerial corrosion, and for alternating corrosion and complete immersion no other material tested was equal to it. A very satisfactory degree of resistance was also obtained for a 3·75% nickel steel under a number of conditions. Chromium steel containing 13·5% chromium, which behaved very erratically in the series of tests, is quite unsuitable for immersion in sea water owing to severe local pitting. Mild steel appears to be unreliable whether descaled or with the mill scale adherent. Addition of copper to mild steel improved its resistance to corrosion on a five-year test, but this superiority was reduced, when the exposure was extended to ten years. The various wrought irons behave erratically but in general show a resistance somewhat similar to the carbon steels. Cast iron although it appears to suffer little on the surface and looks sound, is seriously weakened by internal corrosion and graphitisation.

Influence of Painting

Several series of tests have also been carried out by the above Committee to determine the effect of painting. Steel plates painted with white lead, red lead, red oxide, tar and various bituminous compositions, exposed to aerial attack (sea air) for seven years showed that good oil paints gave adequate protection to steel, particularly where the steel was descaled before painting. The best results were obtained with the lead paints. The bituminous compositions gave inferior results. Similar painted plates exposed to intermittent attack and complete immersion for one year showed the lead paints to afford better protection than the iron oxide to intermittent exposure, but the reverse to complete immersion, although there was more serious pitting under lead paints with both exposures. Bituminous compositions under like conditions gave good protection.

In another series of painted plates exposed to intermittent and complete immersion attack, the larger proportion of the plates were sandblasted before painting and the smaller proportion scraped, exposed to sea water for seven months, washed, scraped, dried, and wire-brushed before painting. These last plates were so treated to imitate the condition of ship plates. After a year's exposure the paint was removed, when it was found that the scraped plates had lost more weight and pitted more than the sandblasted plates. Those exposed to intermittent attack were more irregularly and deeper pitted than those completely immersed, and pitting was less deep with the red oxide paint than with the lead paints.

World's Industrial Output

A comparison of industrial production since 1929 in eight of the chief manufacturing countries has just been made by the Board of Trade. For most of them 1929 was the year of maximum activity, and except in Japan and France there was in the three following years a continuous decline. In 1933 output was higher generally than in 1932, but the rate of recovery varied greatly in the different countries. Last year a further expansion took place except in France and Belgium where production was lower than in 1933 by 7½% and 5½% respectively. The increase in Germany amounted to 25%, in Canada to 22%, and in Poland and the United Kingdom to 13% and 12%, respectively, Japan and the United States recording smaller advances. Japanese output, however, exceeded that of 1929 by about 27%, and the United Kingdom exceptionally among the other countries, almost regained that year's level.

Cold Work Action on Stainless Steel

By Richard Saxton.

The deformation of some metals when cold by pressing ,hammering, rolling, and drawing constitutes one of their most useful properties and the successful application of stainless steels is dependent to a considerable extent on this property. In this article some aspects of the action of cold work on these steels are discussed, particularly in connection with wire drawing.

THE efficient reduction or cold work fabrication of stainless steels, particularly in wire or bar form, demands a wide knowledge of heat treatment and crystal flow, the greater density and lower thermal conductivity, together with readiness to harden rapidly under pressure often presenting problems seldom met in carbon-steel fabrication. In the cold-drawing operation, accomplished by the circumferential pressure induced by the pull of the reduced metal, it is essential there be uniform flow throughout the section, or cross-sectional stresses set up quickly lead to fracture or brittle condition of metal undergoing process.

Many of the steels comprising this group are unresponsive to any form of cold work, their greater hardness rendering any attempt to fabricate in the cold state impracticable, and though those amenable vary in their response to the pressure generated, ease or facility with which they may be cold worked is dependent on carbon content, not on elements imparting stainless properties.

As many readers possess a general knowledge of the principles governing this method of metal fabrication it is not proposed to give a detailed description of the various processes incidental to manufacture, but to illustrate the action of the pressure on the crystalline structure, physical properties imparted, and amount of reduction possible when heat-treated efficiently.

Stainless steels having the widest general use are the 18·8 type, an 18% chromium and 8% nickel combination which, in the austenitic condition, furnishes high toughness, tenacity and ductility. Though liable to harden rapidly and change to the martensitic condition, when subjected to heavy repeated stress, they cannot be hardened by heating and quenching, hardness properties being imparted proportionately to the amount of cold work performed. A combination of good physical properties and resistance to corrosion is achieved where the analysis is confined within close limits: carbon being kept at 0·07% or less and silicon not exceeding 0·4%. In the annealed state this composition is non-magnetic, but a gradual trend to the magnetic occurs with each reduction and resultant increase in hardness.

In the raw or rolled-rod condition material is too hard for plastic deformation (Brinnel 260 approx.), and heat treatment is essential at this stage to soften and eliminate cross-sectional stresses set up by previous cold work. Treatment consists in slowly raising to approx. 1,050° C. (non-scaling atmosphere where possible), and quenching in water. This brings about a re-crystallisation of the solution of carbide and furnishes a homogeneous structure favourable to reduction. Where it is not possible to raise to this temperature the material can be slightly softened by heating to 900–950° C., and coolling in air, but cold work on the resultant condition will be found more difficult.

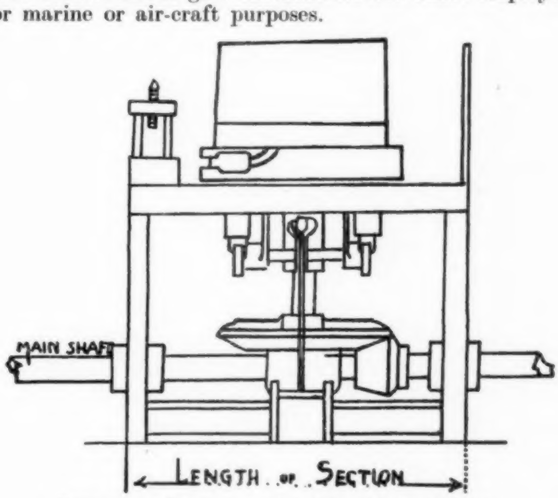
Care must be exercised during heat treatment that little or no halt takes place in the rise of temperature between 530 and 820° C., as there is risk of inter-granular corrosion if maintained between these temperatures for any length of time. In this range of temperature the austenite in a steel of the 18.8 quality is not stable, part of the chromium and carbon coming out of solution. The change which occurs when treatment is prolonged between these figures is detrimental to the quality of the material, particularly if it is subsequently exposed to corrosion influences, when the grain boundaries are attacked with resultant disintegration.

If heat treatment has been efficiently performed it is possible at this, the first stage of reducing operations, to subject the material to an aggregate reduction approximating 60% of dia., this operation follows that of the acid-immersion process, which is essential to remove superfluous matter formed on surface during exposure to heat. As, by the combination of heat treatment and reduction the grain undergoes a refining influence, a change in second or intermediate heat treatment is necessary, and where treated between 940 and 960° C., an austenitic and homogeneous structure is developed favourable to further reduction.

A typical drawing programme for this class of steels in the annealed condition is as follows:—

Reduction I size per draft to	Die.	Process.	Lubricant.
·212, ·190, ·150,	High carbon chromium steel.	Dry.	Soap.
·120, ·100,	High ,, ,,	,,	,,
·060, ·055, ·050,	Tungsten carbide.	,,	,,
·060 to ·040, in multiple,	,, ,,	,,	,,
·040 ,, ·020	,, ,, ,,	,,	,,
·020 ,, ·008	,, Diamond.	Wet.	Oil.

Though the many difficulties incidental to fabrication of stainless steels in wire form have been steadily surmounted, their inclusion in the construction of wire ropes for mining purposes has not yet proved a practical propostion. Wire ropes, however, constructed of cylindrical wires cold drawn to give a tensile stress of 300,000 lbs. to the sq. in., have been found to give excellent service where employed for marine or air-craft purposes.



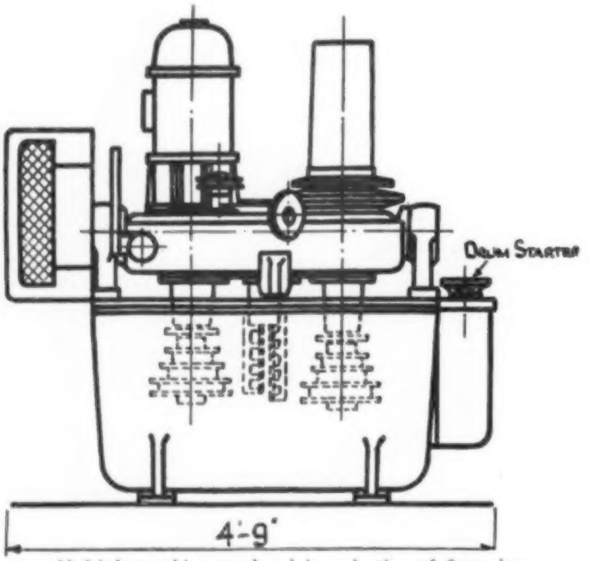
Type of machine as employed for single drafting.

Corrosion is the chief trouble encountered in mining ropes, and while it is possible to eliminate this difficulty by the use of suitable corrosion-resisting steels, the combination of high tensile and ductility necessary in this class of ropes has proved a drawback to their adoption, the highest stress possible in the hardened condition being approximately only 50% that essential in modern-mining practice. The high tensile necessary can only be gained by the inclusion of a higher carbon content, an inclusion which, in stainless material, exercises a very detrimental effect on the cold-working properties of the metal.

The change which takes place in the crystalline structure during passage through the die, particularly with material drawn in cylindrical formation, is as follows: Due to circumferential force imposed the pressure converges on

core, elongating the crystals at this point into fibres. To compensate for the more rapid flow at the core the die bearing is constructed to throw extra pressure on the material at right angles to the line of travel on the outer structure, elongating the crystals here proportionately to those nearer the centre and producing uniformity of flow and slip.

Angle and slope of die bearing varies with all metals, and the milder the quality, consistent with stability to withstand stresses generated, the greater the reduction per pass. During the passage through the bearing there is, first, the initial yield of the crystal cleavage planes, followed, on reaching a certain hardness under the pressure imposed, by slip between crystals. This movement or elongation of the crystalline formation continues with each successive draft until, if reduction is carried to extremes, a brittle condition known as "overdrawn" is reached.



Multiple machine employed in reduction of fine wires.

Though little mention has been made of the acid-cleaning operation (process preceding drawing), the efficient performance of this is essential if the finished material is to retain its non-corrosive properties. Foreign matter adhering to the surface of material must be completely removed during this operation, any remaining will be forced into the metal during drawing and will form pits. Where the reduction is continued it is possible for these pits to be covered over by the subsequent passage of material through the die, and in this condition many of these defects remain undiscovered until corrosion reveals their presence.

For drawing this quality of steel, tungsten carbide dies are recommended in place of the steel type, though the use of the latter in the earlier stages may be advantageous from the view point of wear and tear. Carbide dies employed in the finishing stages are less liable to scratch or scrape the surface, a condition detrimental to stainless properties. Resistance to corrosion is not merely skin deep, but good polish and freedom from cross-sectional and longitudinal stress is necessary to preserve non-corrosive qualities, and material scraped or etched by the wearing of the die is in a stressed condition.

Scraping or etching of the surface is one of the chief difficulties encountered in reduction of stainless steels, by cold work, and where the die shows indication of wear it should at once be re-polished or replaced. Whilst of minor consequence in the earlier stages, if not too deep to remove by subsequent passes, its presence indicates a strain or cross-sectional stress, and steps should be taken to eliminate as early as possible. Where required to be finished to fine limits (tolerance of plus or minus $\frac{1}{4}$-thou. in.), general practice is to replace the last drawing pass by grinding, but as this, though a cold-working operation is not one of applied pressure, its description does not come within the scope of this article.

The cold working or drawing of tubes fabricated of this metal follows practically the same methods as employed in wire reduction, the exception being that tubes are drawn in bar form only, and the wire, for greater convenience, is wound around a drum in the familiar coil. Lubricants employed are precisely similar, but drafting or reduction is not as severe, due to tubes being required to be of a more malleable nature.

Cold material should never be placed in a hot furnace when commencing heat treatment, the best practice being to allow the furnace to fall to 450–550° C., before charging. If this should not be practicable material should be heated as high as possible before charging, but with this method there is still risk of forcing the heat too rapidly into the metal and imparting a condition of corrosion brittleness. Heat and cold work treatment, as described, is applicable to the austenitic or non-magnetic stainless only, and is unsuitable for the higher chromium and nickel qualities.

The Formation of Hot-Dipped Tin Coatings

The formation of tin coatings by hot-dipping involves a number of factors which have not been completely elucidated. The problem is being studied by the International Tin Research and Development Council, and forms the subject of their Technical Publication, Series A. No. 17 :—"Factors Influencing the Formation and Structure of Hot-Dipped Tin Coatings," by E. J. Daniels, M.Sc. This paper was presented to the recent Symposium on the structure of metallic coatings organised by the Faraday Society.

After reviewing previous work, the author considers the mechanism of the wetting of a solid metal by a liquid metal, and shows that, in general, wetting depends on the formation of an intermetallic compound or a solid solution. This leads in turn to a discussion of the intermediate alloy layer which is formed between the basis metal and the tin coating. In a section dealing with fluxes, the characteristics of several new fluxes are described, and an explanation of their action is suggested. Some interesting results are described showing how the manner of solidification of the tin coating depends on various factors. This is of importance since it governs the surface of the coating, which may be smooth, rippled or spangled according to circumstances. Besides the temperature of tinning, and the method of cooling, alloying has a marked effect, and particularly smooth coatings have been obtained by adding small percentages of certain metals to the tinning bath.

Copies of the above paper may be obtained from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C. 2.

Sands, Clays and Minerals

This publication, which has been developed with the object of stimulating British and Empire trade in minerals, is fulfilling its object as succeeding issues show. The present issue, which is not the least important of the series, contains many informative and interesting articles. Some indication of the range of subjects discussed are shown by the articles in this issue, which include :—"Radium Discoveries in Canada," by Dr. H. G. Spence ; "Mineral Resources of Tasmania," by P. O. Lennon ; "Manganese Steel in Crushing Machines," by W. B. Pickering ; "Difficulties in the Manufacture of Firebrick," by C. R. F. Threlfall ; "Quartz Sand in Silica Brick Manufacture," by Prof. P. Budnikoff ; "Zirconium and Its Uses," by L. Sanderson ; "Briquetting Small Coal," by J. B. M. Mason ; "Magnesite and Magnesite Bricks," by C. L. Rigby ; "Ancient Tin Mining," by W. Rice Mitchell ; and "Early English Lead Mining," by J. E. Metcalfe ; being a few of those published in the recent issue. It is published by A. L. Curtis, Westmoor Laboratory, P.O. Box 61, Chatteris, England. Price 3s. 6d., post free.

The Installation and Maintenance of Thermo-Electric Pyrometers—Part 3

By G. H. BARKER

The influence of heat upon the quality and cost of nearly all manufactured products necessitates a thorough understanding of the underlying principles involved and the possibility of controlling the many variable factors affecting the conduct of heating operations. Control of temperature is generally considered the most essential factor, and, to facilitate this, thermo-electric pyrometers are now almost indispensable. In this part the author concludes his discussion on the important factors in the construction, use, and checking of thermo-electric pyrometers.

In single point checking it must, of course, be borne in mind that the accuracy of the equipment is checked at that point only, and if correct at the freezing point of the particular material used, it is not necessarily accurate over the remainder of the scale. Normally, however, it will be found to be an adequate check. Care should also be taken to ensure that the thermocouple is immersed into the salt or metal by the same amount as when in service.

Where it is desired to obtain readings at a series of temperatures with the same apparatus, a standard thermocouple is required. This and the service thermocouple are immersed in the molten metal, and readings taken when a temperature equilibrium is reached. Readings are taken at a series of temperatures.

For the routine checking of service thermocouples, the employment of a muffle furnace is popular practice. This method also entails the employment of a standard thermocouple. The protecting tubes are removed from the service and standard thermocouples, and their hot junctions tied together with asbestos string. The furnace is then brought to a constant temperature, and preferably that to which the service thermocouple is normally subjected. The readings of the thermocouples are compared by transferring the connecting leads from one thermocouple head to the other, or by means of a change-over switch, the temperature readings being taken on the precision millivoltmeter. The accuracy of this method can be improved by inserting the tips of the thermocouples into a block of metal or refractory material within the furnace, as this tends to minimise the variations in temperature and temperature difference.

In checking thermocouples actually in use, the standard thermocouple should be employed with a portable millivoltmeter or potentiometer, and the hot junction of the standard thermocouple placed as near as possible to the hot junction of the thermocouple being tested. It is, of course, essential to see that the same type of protecting sheath is used over the standard test thermocouple as over that in service and every precaution must be taken to duplicate the conditions, otherwise comparison will be faulty.

Often, an extra hole is provided through which the test thermocouple may be inserted. Where this is not available, and the temperature of the furnace is reasonably constant, and an approximate check only is required, satisfactory results may be obtained by removing the permanent thermocouple from the furnace and inserting the standard test thermocouple in its place. It should be noted, however, that time is required for the standard thermocouple to come up to full heat and there is also the danger of the temperature of the furnace changing. While only a relative result can be obtained, it is a convenient rough and ready check on the condition of the service thermocouple and if repeated at regular intervals, will act as a guide to the rate of deterioration.

It is clearly essential also to periodically check the complete thermo-electric circuit in order to make sure that all of the wiring is in good condition. Shorts and open circuits may become apparent, for the search is for poor contact at thermocouple heads, instrument terminals, etc., and poor insulation which may be responsible for faulty operation and incorrect readings.

Radiation Pyrometers. Whilst these notes are intended to deal particularly with pyrometers employing thermocouples, they would be incomplete if reference were not made to radiation pyrometers. The radiation pyrometer is used to measure those temperatures at which a thermocouple would last only a very short time or burn out immediately, but owing to their nature they may occasionally be more convenient than thermocouple pyrometers, even at lower temperatures (700° C. minimum). The radiation pyrometer is not directly exposed to the temperature under measurement, but by means of a lens, or in some cases a mirror, converges a cone of rays from a hot body on to a sensitive miniature thermocouple within the radiation tube. The sighting tube is connected by copper or compensating leads to an indicator or recorder of the type previously described, and calibrated suitably. Radiation pyrometers can, therefore, be of the distance indicating, continuously recording, or controlling types.

The radiation pyrometer employs the radiant energy emitted by the hot body to determine its temperature, and the measurement is based on all the energy emitted—*i.e.*, the heat rays and also the light rays. The intensity of radiation emitted by a hot body varies immensely with the temperature. Unfortunately, all bodies do not emit the same amount at a given temperature, the radiation, for example, from incandescent iron and carbon being very much greater than that from porcelain or platinum at identical temperature, thus, glowing carbon appears about three times as bright to the eye as glowing platinum at the same temperature. This is technically expressed by saying that the emissive power, or emissivity, of carbon is about three times that of platinum.

The material having the highest theoretically possible emissivity is know as a "black body," and this may be taken as an enclosure which is opaque to radiant energy and kept at a constant and uniform temperature. The radiations received from the interior through an opening through the side are "black body" radiations. The

Fortunately, the majority of industrial furnaces sufficiently approximate black body conditions to enable radiation pyrometers to be employed satisfactorily without corrections having to be applied for departures from true black body conditions. In nearly all cases, however, where temperatures are being taken in the open—*e.g.*, of iron and steel ingots, rails, etc., corrections must be used in order to obtain a true reading. With ferrous metals, readily forming an oxide film on exposure to the atmosphere, the correction is reasonably small. As the conditions remain reasonably constant, if the observed temperature is low, it is low by a definite amount so that the conditions can be repeated. In general, however, the optical pyrometer

(not dealt with in these notes) is a more suitable instrument for use in the open.

Where it is inconvenient to have an open-sight hole for using the radiation pyrometer, owing to the entry of cold air and the presence of smoke and dust obscuring the vision, a closed-ended tube should be built into the furnace wall or crown. In all cases, care should be taken to ensure that no fumes or vapours pass between the receiving tube and the hole in the furnace through which it is sighted, as such conditions will obviously cause serious errors in the readings. The pyrometer is then focussed on to the bottom of the tube, and care must be taken to ensure that the thermocouple disc is covered by the image of the hot end of the tube, and that the open end does not cut off any of the cone of rays. The instrument should, therefore, be placed at a distance within approximately fifteen times the diameter of the hole or hot body, but this will vary with the type of instrument used. Another way of employing the radiation pyrometer is to fit a screen of quartz glass over the sighting hole, allowance for this being made in the calibration of the instrument.

The following figures show the correct and observed temperatures when using the radiation pyrometer in the open on solid iron oxide, and compared with molten iron.

Observed Temp. in ° C.	True Temperature in ° C. (These temperatures would actually be shown by the radiation pyrometer were the object black body).	
	Solid Iron Oxide.	Molten Metal.
600	630	
700	735	
800	840	1,200
900	945	1,340
1,000	1,050	1,470
1,100	1,155	1,510
1,200	1,260	1,750

It will be seen that the corrections are very small with a solid incandescent metal, due to the presence of a coating of oxide. In the case of molten iron, and molten metals generally, however, through the oxide film being constantly broken up, the corrections are very large.

The only really reliable method of checking a radiation pyrometer is to sight it on a black body furnace, the temperature of which can be measured by an independent means—*i.e.*, another radiation or an optical or thermo-electric pyrometer. A series of readings is taken at different temperatures.

Where a black body furnace is not available—as will be usually the case in industrial practice—the instrument may be sighted on any furnace approximating to black body conditions. It should be borne in mind, however, that the standard against which a service pyrometer is checked should be another radiation pyrometer of identical type. The radiation pyrometer used as the standard should obviously be one which has previously been calibrated under true black body conditions.

The reader should note that it is useless endeavouring to check a radiation pyrometer against an optical pyrometer or a thermo-electric pyrometer, excepting where true black body conditions exist, and these will usually only occur in a furnace especially designed for the purpose.

The required maintenance of the radiation pyrometer will depend upon its type. If a lens is used, the instrument will be totally enclosed, and all that is normally required is to ensure that the lens is clean and free from scratches or other blemishes.

If the instrument is of the mirror type, similar care needs to be taken to see that the mirror is clean and untarnished, and general cleanliness of the interior will also be required as the front is usually open.

The thermocouple life is almost indefinite, as its temperature does not exceed 200-300° C., but in view of its essential delicacy, shock through rough handling should be avoided as much as possible.

The millivoltmeter, whether integral as in the portable instrument, or external, will require the consideratiou previously described and periodical examination. It may be added that with permanent installations of radiation pyrometers, the sighting of the tubes needs to be checked occasionally, as they may be accidentally disturbed.

Canada's Geological Field Programme

The $1,000,CC0 geological field programme planned by The Honourable W. A. Gordon, M.P., Minister of Mines of Canada, to speed up the geological mapping of prospective mineral-bearing areas throughout the Dominion, is now well underway, according to a communication from the Department of Mines at Ottawa. The movement to designated areas commenced on May 18, when a contingent left Ottawa headed for the Yukon Territory, and in early July the whole field force comprising a total of 830 men were engaged in carrying out the most ambitious programme yet undertaken by the Dominion Government in its effort to aid and encourage prospecting and mineral development.

While the work of the parties will take in the whole range of economically valuable minerals, chief attention is being given to areas in the Canadian Shield and the Cordillera, the two geological regions that provide the bulk of the Dominion s metal output. In mapping and investigating these areas primary consideration is being given to geological occurrences believed to be favourable to gold deposition. So little is known of the geological conditions and the mineral possibilities of several of the areas that the work of the Department this year will be largely of a pioneering nature. Particularly is this the case in British Columbia, in the North-west Territories, and in Manitoba.

Among the large projects related to non-metallic mineral development are those underway in southern Saskatchewan and southern Alberta and in south-western Ontario where studies are being made of structural conditions associated with petroleum and natural gas fields. One such project in Alberta will cover an area of 7,CC0 square miles, while another, which will include part of Saskatchewan and Alberta, comprises an area of 40,CC0 square miles. The south-western Ontario project will cover twelve countries. One project in southern Saskatchewan and south-eastern Alberta calls for the systematic survey of the ground water resources of approximately 1C0,CC0 square miles of country, severely affected by drought conditions of recent years. Non-metallic mineral projects also include investigations in the Thetford asbestos area of Quebec, and geological work in relation to occurrences of coal, salt, gypsum, and iron in Nova Scotia and New Brunswick.

At the close of the field season, maps and reports will be rushed to completion in order to provide prospectors and engineers with strategic information with the least possible delay.

Shipping, Engineering and Machinery Exhibition

At Olympia, from September 12 to 28, there will be held the Shipping, Engineering and Machinery Exhibition, which now incorporates the Foundry Trades Exhibition. With the gradual recovery of trade and the need for replacements and new installation, the wide appeal of this Exhibition should have a considerable influence on its success. Advance information shows that a large number of firms are exhibiting their products and various branches of engineering, as well as the foundry, trades will be strongly represented.

In Germany a well-known petroleum company is buying cast Monel Metal spanners for use in their refinery. The reason for the employment of Monel Metal is that if the spanner slips off a nut and happens to strike an adjacent piece of steel or cast iron there is far less chance of a dangerous spark being created than would be the case with a steel spanner. The spanners ordered have been the usual double ended type.

Correspondence

The Effects of Thermic Treatment upon the Physical Properties of Aluminium Alloys.

The Editor, Metallurgia. 16th July, 1935

Sir,—We have noted the article under the above heading appearing in your June issue, but in the section dealing with Wrought Alloys we consider the writer of the article is in error in comparing a double heat-treatment alloy such as RR.56 with an alloy such as 24ST, which requires a single heat-treatment only, afterwards ageing spontaneously at room temperature.

NA24ST was developed as an alloy, having equivalent corrosion resistance and appreciably better mechanical properties than the ordinary Duralumin or NA17ST type of alloy. The corrosion resistance of such alloys is superior to that of the double heat-treatment alloys such as RR.56.

The alloy comparative to the RR.56 type is NA22ST which, as in the case of RR.56, is supplied in either the solution-treated condition only (NA22SW) or in the solution treated and artificially aged (fully heat-treated) condition (NA22ST.)

It is not clear whether the Tensile Strength figures quoted for RR.56 in Table IV. of the article referred to are intended as guaranteed minimum specification figures, but in the case of NA22ST the following are actual guaranteed minimum specification figures :—

	0·1% Proof Stress Tons per Sq. In.	Ultimate Stress Tons per Sq. In.
NA22ST sheet	23·0	29·0
NA22ST rod	22·0	29·0

It will be noted that the above guaranteed figures for NA22ST are equivalent to those which appear in the article in question as applicable to RR.56.

Gordon H. Field.
Technical Director.
Northern Aluminium Company Limited.

The Editor, Metallurgia. 25th July, 1935.

Sir,—I have noted Mr. Field's letter, and may say I am rather surprised at his manner of criticism of my article.

Dealing with the first paragraph of Mr. Field's letter, I presume that he has taken objection to the Spar Test Summary, which gave comparisons of built up sections in the Alloys ST.24, Duralumin and R.R.56.

The object of this test was to definitely ascertain the physical characteristics of these alloys under representative service conditions, because in this form, the ST.24 Alloy was being strongly advocated as equal to the RR.56, with the added advantage of only a single heat-treatment as compared with the more lengthy double heat-treatment of the R.R. Alloy.

Under the circumstances, therefore, I cannot agree with Mr. Field's statement and his apparent objection to the comparison of an Alloy requiring a double heat-treatment against one only requiring a single heat-treatment.

I note that Mr. Field now offers the NA.22ST Alloy with a double heat-treatment to give equal physical characteristics to R.R.56. I do not question the authenticity of Mr. Field's figures for the 22ST Alloy, but as the tests under discussion were extruded sections of a rather intricate character, I would express grave doubt as to whether Mr. Field's 22ST Alloy would be capable of fulfilling the desired conditions, insomuch as the ST24 Alloy is difficult enough to extrude, and I should imagine the 22ST Alloy would prove to be much more difficult, whereas the RR.56 Alloy is easily workable in this form, and presents no difficulties whatsoever.

I would add further information to these comments, and the results of the Spar Test Summary, by pointing out that the Macro Crystal Structure of the RR.56 and the ST.24 Alloys showed a remarkable difference. Due to its composition, the R.R.56 exhibited an extremely fine macro structure almost invisible to the naked eye, whereas the ST24 Alloy had a very large coarse crystal structure which I would venture to say is somewhat typical of an alloy of this composition, and would equally apply to the ST22 Alloy of a somewhat similar chemical constitution.

I agree perfectly with Mr. Field's remarks regarding the object of the development of the 24ST Alloy to give superior properties to ordinary Duralumin with a single heat-treatment, and would add that it is recognised in present scientific circles that the corrosion resistance of alloys with a single quench is much superior to those embodying the low temperature or artificial precipitation treatment.

The physical properties of the RR.56 given in Table IV. are minimum guarantee properties in the forged and heat-treated condition, and can be exceeded under normal production conditions.

J. Town Robinson.

Metallurgist,
High Duty Alloys Limited.

The Editor, Metallurgia. 7th August, 1935.

Sir,—We have carefully noted Mr. Robinson's comments on our letter to you of the 16th July.

We cannot understand his expression of surprise at what he terms our " manner of criticism " of his article, since the letter referred to was merely a statement of facts, prompted by a desire to give your readers accurate information regarding certain alloys of the super-Duralumin type.

Mr. Robinson assumes we have taken objection to the Spar Test Summary quoted by him in his original article. We wish to assure Mr. Robinson that our comments were not based on the method of testing employed. We consider, however, that statements regarding the origin of the material in question and the number of tests involved, together with the name of those responsible for carrying out the tests, would prove helpful to readers who desire to evaluate and compare such results.

In reply to the third paragraph of Mr. Robinson's letter, we desire to point out that NA24ST has never been advocated as being equal in all respects to RR.56 and, in this connection, we refer chiefly to the 0.1% proof stress. NA24ST is advocated as possessing superior corrosion-resistance properties to a double heat-treatment type of alloy such as RR.56, which point is admitted by Mr. Robinson in the penultimate paragraph of his letter, whilst at the same time possessing equivalent tensile strength and greater workability.

As a matter of interest we might here quote guaranteed minimum specification figures for the single heat-treatment alloy NA24ST, those for the double heat-treatment alloy NA22ST having already been quoted in our previous letter :—

	0·1% Proof Stress Tons per Sq. In.	Ultimate Stress Tons per Sq. In.
NA24ST Sheet	18·0	28·0
NA24ST Rod (up to 4 in. dia.)	18·0	28·0
NA24ST Rod (above 4 in. dia.)	17·0	27·0

In view of the above, we still adhere to the opinion previously expressed by us that Mr. Robinson was in error in comparing a double heat-treatment alloy such as RR.56 with a single heat-treatment alloy such as NA24ST, developed to supply a different need, instead of comparing it with other double heat-treatment alloys such as NA22ST.

It will be of interest to point out that alloy NA22ST, although a double heat-treatment alloy and a " super-Duralumin " from the standpoint of its high mechanical properties, is not a new alloy, as Mr. Robinson implies, but one with which there has been considerable practical experience. It is in fact covered by British Patent Specification 191,024, granted in 1923.

Mr. Robinson suggests that NA22ST would be an

especially difficult alloy to extrude and more susceptible to coarse-grain growth than RR.56 alloy. Extrusion difficulties and grain growth tendencies are characteristics subject to modification by the working and heat-treatment technique, and there are many exceptions in practice to any general statements which can be made concerning them. We think it sufficient to say here that we have not found the alloys NA22ST and NA24ST to be particularly difficult to work nor to produce with a fine grain structure in any of the wrought forms.

We are pleased to note that your contributor confirms our remarks as to the respective merits of single and double heat-treatment alloys from the corrosion resistance point of view.

We thank Mr. Robinson for making clear that the figures for RR.56 quoted in Table IV. of his article, apply to the alloy in the forged and heat-treated condition only, since it rather appeared as if they were intended to apply to RR.56 in any wrought form. By minimum guaranteed figures we assume he implies such as would be applicable to any proposed British Standard or Government Specification, on which basis our own figures for NA22ST and NA24ST have been quoted.

Gordon H. Field,
Technical Director,
Northern Aluminium Company Limited.

The Consolidated Mining and Smelting Co., of Canada, Ltd., is about to spend approximately $2,500,000 in expanding by 38 tons daily the ammonia capacity at the fertiliser plant near the Trail smelter, whilst absorption plants are to be built for the recovery of the remaining sulphur dioxide from the zinc plant gases, and to build acidifying plants to release the sulphur dioxide. About 54 tons of elemental sulphur are also to be recovered daily.

Manchester Metallurgical Society

Mutual Co-operation with Iron and Steel Institute

With the object of extending the advantages of the Iron and Steel Institute and particularly to encourage the study of problems connected with the manufacture and metallurgy of iron and steel, arrangements have been made for mutual co-operation between this Institute and certain local Technical Societies, one of which is the Manchester Metallurgical Society. According to these arrangements the Iron and Steel Institute has agreed to extend the maximum age of Associate Membership of the Iron and Steel Institute from 24 years of age, as previously fixed, to 30 years of age in the case of Associate members who are also members of this Society. Associate members of the Iron and Steel Institute are entitled to receive the Journal and other publications free of charge, and to enjoy all other facilities extended to members, including the use of the Loan Library, but are not entitled to a vote at general meetings. The subscription is one guinea a year (instead of three guineas for full membership), and the payment of an entrance fee (two guineas in the case of full membership) is waived; no transfer becomes payable on transference to full membership.

(This arrangement does not apply to Members of this Society who are under 30 years of age, but who are already full Members of the Iron and Steel Institute).

The Council of the Iron and Steel Institute offers to supply each year to this Society, for presentation and discussion at meetings, certain papers which have been presented at the General Meetings of the Iron and Steel Institute. It is proposed to hold one or two joint meetings each session between members of this society and members of the Iron and Steel Institute resident in the Manchester district. The Secretary of the Iron and Steel Institute, 28, Victoria Street, London, S.W. 1, would be pleased to supply further information of this arrangement on request.

Tin Consumption Analysis

The world production of tin in the first five months of 1935 totalled 45,089 tons, an increase of 3,032 tons over the production for the corresponding period of 1934, according to the July Bulletin of the International Tin Research and Development Council, issued by the Hague Statistical Office.

The apparent world consumption of tin shows a 15% increase this year, the figures for January to May being 56,243 tons in 1935, against 48,931 tons in 1934. During the year ended May, 1935, many countries showed considerable increases in consumption, including Russia with an increase of 15.1%, Canada 29.2%, Holland 25.0%, Japan 15.1%, India 15.5% and Sweden 17.2%. The consumption of the principal countries is shown in the following table :—

	Year Ended May, 1935. Tons.	1934. Tons.	Increase or decrease Per Cent.
U.S.A.	50,960	58,117	— 12·3
United Kingdom	21,215	20,212	+ 5·0
Germany	9,922	11,007	— 9·9
France	8,753	9,590	— 9·9
U.S.S.R.	5,901	5,126	+ 15·1
Other Countries	28,241	25,589	+ 11·0
Apparent world consumption	124,993	129,641	— 3·6

The Stock Position

The visible stocks of tin at the end of June, 1935, are reported at 15,301 tons, a decrease of 2,886 tons from the previous month. In comparision with the annual averages for the past twelve years, these stocks are at their lowest level since 1926, but in relation to consumption they do not appear excessively low, being 12% of the present annual rate of consumption. "Invisible" stocks in the U.S.A. have been reduced during 1933 and 1934 to approximately the same levels as were maintained from 1926 till 1928.

Consuming Industries

Continuous improvement is shown in the statistics of automobile outputs. In May, 1935, the world output was 479,000 vehicles, against 433,000 vehicles in May, 1934, and in the year ended May, 1935, it was 4,339,000 vehicles against 3,470,000 in the previous year—an increase of 25%.

The tinplate industry has also shown improvement, the world production in May, 1935, being 318,000 tons, against 292,000 tons in May, 1934. The following figures are given for the exports of tinplate from the principal producing countries during 1934 :—

World consumption in manufacture (approx.)	132,500	138,900	— 4.6
Approx. depletion of consumers' stocks	7,500	9,250	

With the exception of Italy all the above countries show a decrease in exports of tinplate this year.

Tin Consumption in Recent Months

The world's apparent consumption of Tin in May, 1935, was 12,222 tons, compared with 11,402 tons in the previous month and with 10,501 tons in May, 1934. The apparent consumption in the United States in May, 1935, was 6,129 tons against 4,389 tons in May, 1934; in the United Kingdom 1,406 tons against 1,582 tons, and in other countries 4,687 tons against 4,530 tons.

The introduction of electric melting is gradually changing conditions in both ferrous and non-ferrous melting shops, and two brochures on the subject recently published by Electric Furnace Co., Ltd., 17, Victoria Street, London, S.W. 1, will be read with considerable interest. One deals with the Ajax-Northrup high-frequency furnace which has been developed for melting high-grade steel, and the other concerns the Ajax-Wyatt induction furnace which is of special value in the brass melting shop. Those interested should obtain copies of these brochures.

Recent Developments in Materials, Tools & Equipment

A MODERN TESTING MACHINE

THE modern type of hydraulic testing machine has so much to commend it that it has almost entirely displaced the old type of machine. The disadvantages of the hydraulic machine have been entirely eliminated in recent designs and the desirable characteristics brought to perfection. For accuracy and ease of control the hydraulic machine is pre-eminent.

The small machine illustrated in Fig. 1 is typical of the latest testing machine practice and designed especially for the metallurgist, both for routine testing and scientific investigation. The cylinder is placed at the top. The piston is of hardened steel ground and lapped to give the requisite clearance in the cylinder to maintain a film of oil between the piston and cylinder walls, under which condition there is no friction, so that the hydrostatic pressure is a true indication of the load on the specimen. There is a slight viscous drag, but this is compensated for in the dynamometer and does not affect load measurement.

The load is applied by a variable-output pump, fitted with a control wheel and indicator to show the rate of straining. No valves are used, the control enables the rate of strain to be varied at will from zero to a maximum. Straining rates as low as 0.001 in. per minute are practicable to enable extensometer readings to be taken without stopping the machine.

The load may be measured either by a self-indicating pendulum dial or by a micrometer dial poise arm as illustrated. The latter is preferable as it is more accurate—simpler in construction, and offers advantages impossible with the former type.

A uniform rate of loading or a uniform rate of strain is an essential feature of modern testing and strangely enough recent specifications for most materials except metals specify the rate of loading or the rate of strain, and yet it has been shown that the rate of loading has an important influence on the behaviour of metals. The machines manufactured by Messrs. A. Macklow-Smith, have a simple device to apply automatic loading whereby the load may be applied uniformly at any desired rate; the poise is mechanically propelled along the poise arm only so long as the arm is in equilibrium and stops instantly at maximum load. A load-sustaining device enables the load to be maintained constant indefinitely. Formerly one of the disadvantages of the hydraulic machine was the falling away of the load if the operator neglected the controls. This device is automatic and enables a hydraulic machine to be used for "creep" and other prolonged tests, any change in the length of specimen is taken care of automatically and the poise lever remains in equilibrium without hunting.

The 10,000 lb. machine measures the load to 1 lb. throughout its range, and these machines are sensitive to about this amount, which is approaching the practical limits of measurement.

The machine illustrated is fitted with an autographic recorder which graphs the load-extension to any desired scale. The pen travels axially along the drum in unison with the poise, thus giving an accurate indication of the load. The extension over the gauge length of the specimen is transmitted to the recording drum through a rocker bar to multiply the actual extension 1, 2, 5 or 10 times, enabling the yield, however small, to be clearly indicated as well as the plastic stage and total extension.

An automatic-strain indicator is shown on the machine illustrated. This indicates the extension of the specimen to 0.01 in. by the rotating dial which stops automatically at fracture, indicating the total extension which the operator may observe at his leisure.

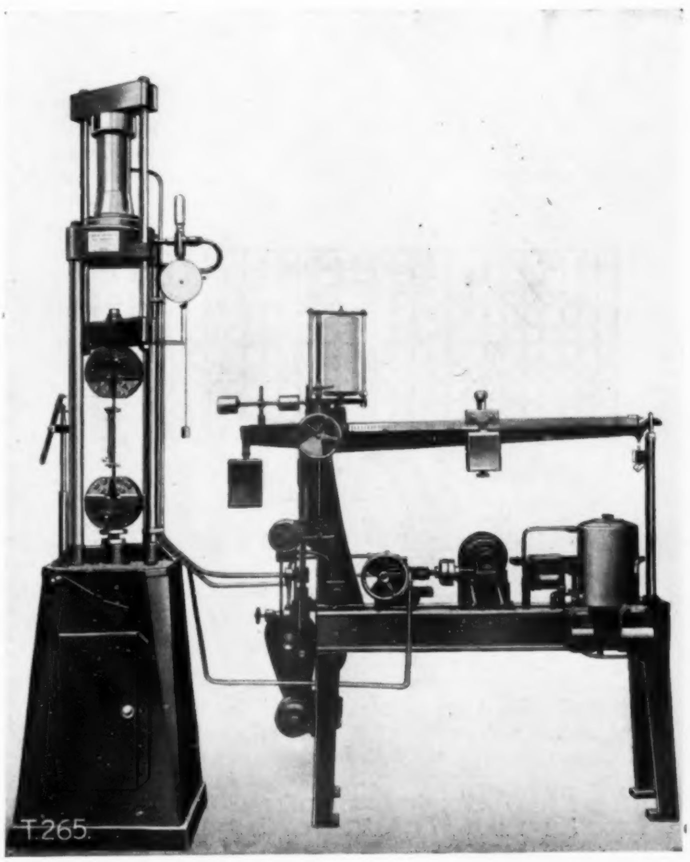
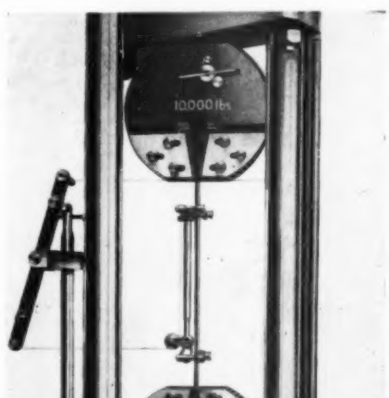


Fig. 1. Typical modern testing machine operated hydraulically.

Fig. 2. Precision Grips for holding small specimens.



Special attention has been given to holding small specimens without preparation for precision testing. The precision grips illustrated by Fig. 2 are the open-sided spring loaded wedge type to accommodate flats and rounds. They are self aligning and readily detached. Thin flat sheet up to $1\frac{1}{2}$ in. wide is securely held and loaded axially and rounds ranging from fine wire to $\frac{5}{16}$ in. diameter are securely held in one set of grips. The saving of costly preparation of specimens and the time saved in set-

ting them up in the machine will be appreciated by all who have a large number of tests to carry out.

Provision for transverse testing and compression may be added if required and a slight modification gives accommodation for ropes, wires and other specimens of unusual length.

The calibration is of a permanent nature and cannot easily be disarranged, but may be readily checked at any time by a small standard weight.

These machines are economical in initial cost and upkeep. A $\frac{1}{4}$-h.p. motor supplies the power and the few wearing parts are hardened and operate in oil. A similarly constructed machine has effected 25,000 tests and the only repair has been the trueing up of the compression faces.

An interesting use to which these machines have been put is the control of sheets for deep drawing. A number of users of deep-drawing sheets attach considerable importance

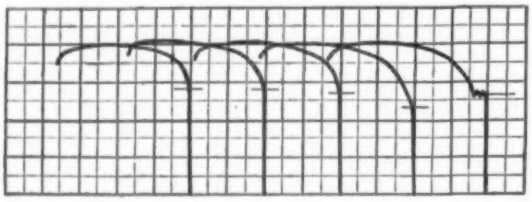


Fig. 3.—Diagram showing increasing amount of cold work on same sheet.

to the tensile test, especially the plastic stage, as an indication of the deep-drawing qualities. Messrs. Baldwins, Ltd., take routine tensile tests, with and across the grain, on deep-drawing orders. This machine provides quick and accurate testing, and the sensitiveness is such that no difficulty is experienced in recording the yield point. They do not as a rule take stress-strain diagrams in routine testing, but find them very useful and informative in special cases. When a record of a tensile test is required the diagram gives the required information in a convenient form. As an example Fig. 3 gives a reproduction of diagrams taken during the investigation of the effect of an increasing amount of cold work on the same sheet. The right-hand diagram represents the sheet in the heat-treated condition before any cold working had been applied. The succeeding diagrams towards the left show the effect of increasing the amount of cold working. The effect of cold rolling on the yield point is clearly shown on these diagrams. Taking the test figures in conjunction with the stress strain diagrams they trace satisfactorily the effects of the cold rolling on the yield point, ultimate stress, elongation, etc. For the purpose of this particular investigation an extension scale of 2 to 1 was used, the diagrams being sufficiently large, but had it been desired a larger scale could have been selected and the behaviour of the yield point examined with greater accuracy. Messrs A. Macklow-Smith, of Westminster, manufacture these machines in all capacities up to 100 tons.

Fused Silica Ware

Some Applications in Metallurgy

One of the most striking developments in recent years is the manufacture of "Vitreosil" fused silica ware, which is of great importance for the metallurgical and allied industries, both on the large scale and in the laboratory. Thus in the latter connection a whole range of equipment is now available, including combustion tubes, dishes, plates, coils, flasks, and stills.

Also, for example, as regards combustion tubes a great variety of forms can now be obtained, made if necessary with a transparent observation window at the centre or other part of the tube, and supplied either with ground-glass connections for gas-tight coupling to other apparatus, or with fused ends, reduced or otherwise, for use with rubber tubes or rubber stoppers.

Some typical applications also of fused silica of this kind on the large scale are tubes for the heat-treatment of wire, rods, and other metal objects, pyrometer protection sheaths, gauge glasses for super-pressure boilers, and permanent windows for combustion chambers of all types. Great advances have also been made in recent years with regard to the size of equipment of this type, that can be manufactured including for example very large condenser coils for nitric, sulphuric, acetic, and other acids in lengths of over 60 feet and up to 3 in. bore.

Vitreosil fused silica ware is a production of the pioneer firm in this field, the Thermal Syndicate, Ltd., of Wallsend-on-Tyne who commenced detailed research work in 1903 and finally evolved a patent process of melting silica at about 3096–3272° F. (1700–1800° C.), using an electrical method, consisting essentially of a carbon rod through which a powerful electric current is passed while lying in the raw material. This may be rock crystal, geyserite (very small rock crystals), or certain varieties of sand, which, along with the exact method of operation, largely determine whether the product is transparent, translucent,

"Kendal" stills of opaque and transparent silica for the preparation of absolutely pure distilled water, with a negligible degree of electrical conductivity, since silica ware, unlike glass, is completely insoluble in water.

or opaque. In all cases the ware is 99.8% SiO_2 or over, and has the same properties, the degree of transparency being determined by the presence of minute bubbles of entangled air or gas.

Fused silica ware of this character has some remarkable properties, due largely to its very high resistance to acids and the almost complete absence of expansion on heating. For this reason silica ware apparatus can be heated white hot in a blow-pipe and then plunged into cold water without any ill effect. Thus the actual co-efficient of expansion within a range of 0–1,000° C., is the extremely small figure of 0.00000054 per 1° C., which is about $\frac{1}{17}$ that of ordinary glass and $\frac{1}{10}$ that of Jena glass.

It will be remembered also there is available a special nickel-alloy steel (36% nickel), known as "Invar," which has such a negligible degree of expansion on heating that it is used in the manufacture of high-grade clocks, so as to avoid pendulum compensation. This remarkable material, has a co-efficient of expansion of only 0.000009, nearly twice, however, that of fused silica ware.

The latter also can be used at temperatures up to, say, 1,832° F. (1,000° C.) or over, and the value, therefore, for all kinds of metallurgical and general heat-treatment plant and equipment will be obvious.

It may be stated further that silica ware is resistant to every known acid, hot or cold, and whether mixed or otherwise, except hydrofluoric and phosphoric, while it possesses high electrical insulating properties and is transparent to the short waves of ultra-violet rays, for this reason another of the most important fields of application is the manufacture of mercury arc lamps.

A SCIENTIFICALLY DESIGNED BUNSEN BURNER

THE novel constructional features of the new Amal burner, and the various practical advantages which they are designed to secure, were referred to in the November, 1934, issue of this Journal, but it might be of interest to describe here some small but important modifications of the main principle which have been recently carried out by the manufacturers. These new features include a pressure-damping device, enabling the flame to be turned down still lower, and the provision of a set of detachable heads, which now equip it to meet practically every laboratory heating requirement.

Besides many distinctive features of its own, the burner may be regarded as embodying the advantages of the Teclu, Meker, and Castell-Evans types. It will give as small a flame as an Argand for purposes of evaporation and gentle charring (such as for vegetable materials which are to be ashed), a compact and perfectly stable hot flame with the unburnt zone confined to the base of the flame, as in the Meker, but which cannot strike back on the jet, and a large flame for boiling or distillation in large vessels.

A Range of Loose Heads

These general purposes should be considerably extended by the range of chromium-plated loose heads now provided. The illustration (Fig. 1) shows the complete range of five loose heads made for the smaller size burner, also here shown side by side with the larger model for comparison. The head part of the air tubes of both sizes are now turned to definite limits of diameter to take the loose heads, two separate sets of which are available for the two sizes, with the exception of the special dental head and cap shown on the left, which is made to fit the small model only. This dental head gives an ordinary hot bunsen flame projecting at a convenient angle, and which can be rotated into any desired position : when making up a denture with such a flame, molten wax cannot drop into the burner and choke the jet, or even on to the burner stand. A quick change-over from the ordinary bunsen flame to a small luminous flame, such as might be required for use with sealing wax, is effected by putting on the small tip, shown in position in the photograph.

Showing the wide range of fitments.

Also shown are the four standard loose heads, designed respectively for giving a horizontal rose flame, flat horizontal and vertical batswing flames, and an ordinary round vertical bunsen flame. The value of a readily-controllable rose flame which can be turned down very low will be recognized where, for example, it is desired to heat large beakers in which bumping is to be particularly avoided, and the horizontal batswing should be useful for heating large vessels which cannot be reached from underneath. The practical advantages of a really hot batswing will be recognized by all glass-blowers, and laboratory tests have shown that with these attachments the burner will give a flat flame some 100° C. hotter than that obtainable with an ordinary bunsen, and in which even Pyrex glass tubing will soften. The glass-blower is further catered for by the provision of a small hole at one side of the vertical batswing head, which admits of a little hot pin-shaped flame for spot-heating.

Stability and sensitivity of flame control are in no way affected by any of these loose heads, which have been specially designed to suit the proportions of the burner.

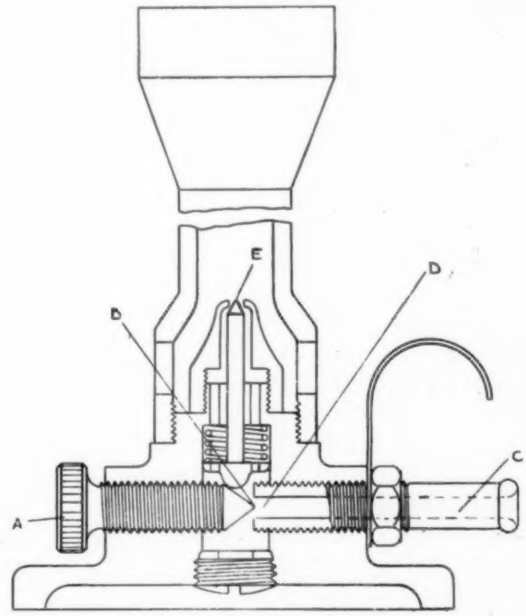


Fig. 2. Press-damping device.

Press-Damping Device

A still lower steady flame has been made possible by the incorporation in both models of a simple pressure-damping arrangement, which is only called into use for the smallest flames that the burner is capable of giving. Its function is to regulate the flow of gas in proportion to the size of the jet orifice, and its operation will be made clear by reference to the sectional diagram (Fig. 2). As the knurled-head screw (A) is screwed in, the flame size is reduced by the lifting of the needle valve (E) on its spring seating by the conical end (B), which at the same time enters the gasway (D). A rubber pipe (C), fixed in position in the gas inlet by the lock nut shown, forms the pressure damper proper, and as the point of the needle approaches its extreme uppermost position in the ejector and the flame size is reduced, so is the gas pressure before the jet correspondingly reduced by the taper end of the regulating screw entering this rubber pipe connection. The point at which it does this may be varied by moving the pressure damper backwards or forwards in the gas inlet pipe, but its position is set at the works, and for normal working with town's gas it may never require to be altered.

Use with Petrol Gas

The smaller size burner is now also obtainable in a design specially suited for petrol-gas consumption. When it is considered that the richest mixture obtainable atmospherically with petrol gas contains about 93% of air, and that it cannot, like coal gas, be simply burnt at the end of an open tube, it becomes obvious why burners of carefully considered design have to be used if the fullest advantage is to be taken of the exceptionally high flame temperature of petrol gas. The correct proportions between the gas outlet and the air inlet in a petrol-gas burner differ appreciably from those in a coal-gas burner, in addition to which, in a satisfactory petrol-gas burner, provision must be made for the correct amount of secondary air necessary for complete

combustion. For practical purposes also, the burner must be reasonably foolproof, and should be so constructed that the air mixture can be maintained as consistent as possible with all variations in the size of the flame without the need for frequent and delicate adjustment.

All these rather exacting requirements are fulfilled by the Amal petrol-gas burner, which has been shown in exhaustive tests to give excellent results with petrol gases from Silverlite and Aerogen plants. In simplicity of principle and operation it differs but slightly from the town's gas burner, but in place of the seven holes at the base of the air tube, there is a single hole for the admission of secondary air which is regulated by a spring-band clip. Once this has been adjusted to give a stable flame, further adjustment is unnecessary, and the size of the flame can be varied to almost any extent without in any way impairing its efficiency.

It has been found that the burner will work with petrol-gas from ½ in. to 2½ in. water gauge, but below about 2 in. the gas velocity at the jet should be suitably increased by screwing in the knurled head screw. With a correctly set pressure-damper, functioning is automatic on adjustment of the screw. For petrol gas, there may be no necessity to use the pressure damper at all, although it may have to be screwed in or out respectively, if the flame shows a tendency to float away or burn yellow or green at small jet openings. The burner should be started with no secondary air, and with the adjustment screw well out: the secondary air port may then be adjusted to its optimum opening.

Loose heads have not yet been designed for use with this petrol burner. The burner base has been enlarged to a more convenient size which is now standard for both models, and for convenience in dismantling a small stop screw is now fitted at the side of the burner base to prevent the needle dropping down when the adjusting screw and gas pipe connection are screwed out.

In general, although surprise may be expressed by some at the engineering care and skill lavished on improving what is perhaps the least elaborate of laboraory necessities, it will be agreed that the result has been a heating instrument of such exceptional range and flexibility of use as should amply justify increased initial expenditure in a modern research laboratory, where critical work goes hand in hand with economy of method. This scientifically designed bunsen burner is produced by Messrs. Amal, Ltd., Birmingham.

The Study of Petrography in U.S.S.R.

To a considerable extent vast areas of the U.S.S.R. are unexplored territory, but, during recent years, much progress has been made in studying problems relating to the origin and properties of rocks and many important discoveries have been made. In this article the writer reviews briefly the work in progress.

The Institute of Petrography under the Academy of Sciences of the U.S.S.R., is one of the few institutions in the Union working on problems relating to the origin and properties of rocks. It carries out this study in various ways—by experimental work in laboratories, examination under the microscope, and by expeditions. The Institute has made a special study in the U.S.S.R. of surface rocks, and those in the upper layers of the earth's crust of ancient volcanoes.

In 1924, when Academician F. Y. Levinson-Lessing, the director of the Institute, brought samples of molten basalt from France, the Institute commenced to study the production of this substance in the Soviet Union. Working in close contact with the Institutes of Metals and Applied Mineralogy, the Institute began to study the suitability of the following materials for producing composition stone: Onega diabase from Karelia, Armenian basalts, Ukrainian veined basalts and others.

The work showed that the Soviet Union contains a rich variety of rocks which can be used as raw materials for producing composition stone, out of which articles can be made for electro-technical purposes and high-voltage insulation. Articles calling for special hardness and resistance up to 7,000 kg per sq. cm. can also be manufactured of composition stone.

Magnetic Properties of Rocks.

The Institute has also made a close study of the magnetic properties of rocks, of great importance in establishing the chemical composition of iron and aluminium ores. Further, the systematic study of the specific resistance and dielectric constant of rocks carried out by the Institute made it possible to supply surveyors with a considerable amount of valuable comparative material characterising the magnetic properties of individual types of rocks. At present, the properties of such rocks as granite, Armenia lava, Siberian basalts and several others are being studied.

Of great practical interest is the work carried out by the department of technical and applied petrography. Here the work of the Institute is closely connected with the demands made by the ceramic and metallurgical plants of the U.S.S.R. and answers their current production needs, helping them to regulate the work of furnaces, to improve the quality of production, and so on. Here are made systematic analyses of refractory bricks from numerous plants of the Union. The Institute then points out to the plants whatever defects there may be in the production of such bricks and indicates changes in their composition.

This department is also engaged in the study of rocks used in building. The mechanical properties and deposits of marble, granite and diabase have been studied.

Finally, one of the most important branches of work undertaken by the Institute is the research work carried out by expeditions on definite scientific problems.

The U.S.S.R. has only one region of active volcanoes—Kamchatka. A systematic study of these volcanoes was commenced by the Institute in 1934, when the first expedition was sent to the region of Klyuchev volcano.

Since 1927 the Institute has widely developed the study of lava and extinct volcanoes in the south of the U.S.S.R.—the Ukraine, Caucasus and Transcaucasia. Several of these volcanoes have been studied in detail and the results published in two volumes—"Karadag," by Academician Levinson-Lessing, and "The Extinct Volcano Alagez and Its Lava," by Professor P. L. Lebedev.

In the course of a number of years the Institute has studied the volcanic formations of the Armenian plateau, the surroundings of Lake Gokchi (Sevan), the Akhalkalak volcanic hills and other districts. In addition to its scientific interest this work is of great practical importance. For instance, research carried out in the district of Lake Gokchi and Zanga River gave a clear picture of the geological structure of a district capable of having powerful hydrotechnical units, and helped the designers of the Gyulush Electric Power Station, the Kanakir construction scheme and the Egvart water reservoir.

Owing to the work of the Institute of Petrography and other institutions carried out in the Khibin and Lovozer tundra on the Kola Peninsula, apatite deposits were found. Around these a new town has sprung up. The enormous deposits of apatite provide a vast source of raw materials for the production of chemical fertilisers, which are not only supplied to the state and collective farms of the Soviet Union, but are also exported.

In addition to apatite a number of other valuable minerals were found, many containing the rare elements of zircon, tantalum, nobium and others.

Reviews of Current Literature

Molybdenum Steels

Their Manufacture and Application

Studies on molybdenum steel may be considered to have been initiated by Dr. T. Swinden, whose work on the subject was published in the Carnegie Scholars Memoirs of the Iron and Steel Institute, volume III, 1911, and volume V, 1913. He made a thorough study of the effects of molybdenum on steel, and his reports give an accurate picture of the effects of molybdenum. Since that time many workers have given attention to the use of molybdenum as an element in alloy steels, and so valuable has it been proved that its use during recent years has developed at a rapid rate. The increasing use of this element is not due to any distinctive cleansing or deoxidising effect, but to the important influence it exerts in the improvement of the mechanical properties of steel both at normal and elevated temperatures

It has been established that a few tenths per cent. of molybdenum in combination with another alloying element such as chromium produces very desirable effects in steels; the same is true when molybdenum is added to steels containing manganese as an alloying element. Further work has shown that a small quantity of molybdenum tends to decrease the loss in strength resulting from heating to temperatures up to 500° to 600° C., and that low-carbon, low-molybdenum steels can be used in boiler construction and other types of service where it is desirable to use a steel that maintains its resistance to creep at moderate temperatures. The resistance to deformation at moderate temperatures is conferred by molybdenum and by the similar element tungsten upon a wide variety of ferrous alloys both pearlitic and austenitic.

Investigations have shown that a small quantity of molybdenum decreases the susceptibility of nickel-chromium steels to temper-brittleness. It is noteworthy also that practically all the steels now used for nitrogen hardening contain some molybdenum, chiefly because the element prevents the steels from becoming brittle at the temperature used. It is now recognised that molybdenum serves to eliminate temper brittleness and to remove many difficulties associated with the fabrication of temper brittle steels, which are so characteristic of many alloy steels. In addition to these improvements, molybdenum reduces the effect of mass, increases the effective tempering range and generally makes it possible to produce steels which will respond to simple heat-treatment. For confirmation of these and many other improvements and how they are obtained this book will prove valuable; it deals with the functions of molybdenum, mainly from a practical point of view, so that users and manufacturers will appreciate its value as a constituent of quality steel, whether of a simple or complex character.

Discussion of the effects of molybdenum additions to steel involves consideration of the mechanical properties of the various combinations of steels also obtainable and the authors give explanations of terms used in order to make the data recorded uniform and definite. The sources of molybdenum are given, the alloys and compounds briefly discussed, and analyses and details given of the commercial materials for use in the different melting processes in the manufacture of molybdenum steels. A useful additional chapter gives methods for the determination of molybdenum in various metallurgical products.

In a chapter dealing with the addition of molybdenum to steel, details are given of the product recommended for use according to the melting process employed and the recovery of the element which may be expected is indicated. Probably the acid open-hearth furnace is responsible for the largest production of molybdenum steels and it is natural that the authors should give greater attention to this process, including casting of the steel, treatment of ingots and castings after casting, and the segregation of the alloy in the steel. Forging, rolling and stamping of molybdenum steels is discussed in a very interesting and informative manner, while much attention is given to heat treatment which incorporates useful data.

The characteristics and properties of the more important types of molybdenum steels are discussed; these include carbon-molybdenum, copper-molybdenum, chromium-molybdenum, manganese-molybdenum, nickel-molybdenum, nickel-chromium-molybdenum, and special molybdenum steels, all of which have long passed the experimental stage, large quantities having been made and put into service, so that they can be recommended to fill the requirements for the great majority of purposes where steels possessing special properties are necessary.

In order to obtain reliable test figures of various types of alloy steels in general use the authors made arrangements with the Sheffield Testing Works for samples to be obtained from makers' stocks of a suitable range of products. The test sheets are given in detail, and their examination shows the tests were very severe, they give facts which no user of good quality steels should miss investigating.

This book is well written, the authors have been more concerned with facts, and these are presented in a very lucid manner. It is printed on heavy quality art paper, which shows the numerous illustrations to advantage, and it is admirably bound. Despite the considerable expense which must have been incurred in its preparation, only the nominal price of 5s. per volume (post free) is being charged. On the other hand, the publishers advise us that they will be pleased to send copies gratis to responsible people in the steel and engineering industries.

By Julius L. F. Vogtel, M.I.E.E., M.I.M.M., and W. F. Rowden, with a Foreword by Lord Riverdale of Sheffield. Published by High Speed Steel Alloys, Ltd., Widnes, England. Price 5s. post free.

Machine Drawing

This book has for many years, been of great value to engineering students in science and technical schools and colleges, and the revised edition recently published will continue this useful service in the future. The method of projection adopted throughout this book is that recommended by the British Engineering Standards Association, and is based on the principles of projection which have always been applied most rigidly in solid geometry. To the student in particular, it is important that the representation of mechanical engineering details on paper by orthographic projections should be by one standard method, a point which the authors have always stressed, in this way loose and incorrect methods of projection can be eradicated from engineering drawing offices.

In addition to 79 plates the book contains numerous explanatory isometric drawings and the salient features of each drawing are described. This book and its authors are too well known among students and teachers to need emphasis here, on more than one occasion it has been spoken of as the machine-drawing teacher's friend and since the revised edition has been increased by several additional plates, it will continue to supply the needs of engineering students as in the past.

Book I. By the late Thomas Jones, M.I.Mech.E. and T. Gilbert Jones, M.Sc.; published by John Heywood, Ltd., Deansgate, Manchester, 3. Price 6s. (postage 6d. extra) in Great Britain.

Principles of Phase Diagrams

Metallurgical literature now contains a large number of phase diagrams, of which many are complicated. These diagrams, variously known as equilibrium, phase, state, and constitutional, are useful physical chemistry, and the more specialised fields of metallurgy and geophysics. Just what such diagrams mean, however, seems to be understood by a relatively small proportion of the persons who come into contact with them. They are an expression of the results of experiment and enable the chemist to collate and appreciate the significance of the work done; many data could not otherwise have been interpreted usefully. Especially is this true in the industrial applications of

chemistry, which include the work of the metallurgist both in getting metal from the ore and in discovering, making, and properly treating the metal or alloy which is best fitted for a particular purpose.

The aim of this book, which is included in the Monograph Series of the Alloys of Iron Research, is to set forth, as simply as possible, yet rigorously and briefly, how these principles serve to inteperet correctly, and to correlate, the many, seemingly quite different, cases which actually arise, even in systems of not more than three compounds. The reason for it is to obviate the necessity of discussing questions of interpretation of phase diagrams and diagrams of state in each of the monographs. The authors were set a difficult task to state, in convenient and practical form, the main theorems and to outline the reasoning involved in the derivation and practical use of these theorems, a task which they have performed with remarkable lucidity.

The treatment of the subject is divided broadly into two parts : In the first the authors show what diagrams mean ; the second is devoted to examples of diagrams. It is demonstrated that all diagrams are related, and that the complex are deduced from the simple by a series of simple steps. The first part is also divided ; the first chapter giving a simple discussion of the underlying principles of the science to which diagrams belong. Certain aspects of these principles are expanded in the second chapter. Succeeding chapters illustrate phase diagrams—first the simple, then the more complex. In so doing the authors demonstrate that the complex representations of multi-component systems can be deduced from the simple diagrams by a series of simple steps. It is shown also that there are certain rules which may be used to guide correct thinking and construction.

This book will prove particularly useful to the younger metallurgist, and to students, who, with a thorough grounding in the principles of chemistry, frequently consider their observations as different aspects of a consistent whole rather than view the behaviour and properties of metals and alloys as a number of largely unrelated facts.

By J. S. Marsh and John Johnson ; published for The Engineering Foundation by the McGraw-Hill Book Co., Ltd., Aldwych House, London, W.C. 2. Price 18s. net.

Electric Melting Practice

Until recently electricity was commonly regarded as an extravagant melting medium. Probably this opinion was held because of the custom of comparing the cost of generating a given number of B.th.u. of electrical energy with the cost of providing an equivalent number of heat units by other means, without making proper allowance for higher efficiency obtainable from electricity in a properly designed furnace. In fuel-fired furnaces the thermal efficiency is so low, and the transfer of heat by electricity so high, comparatively, that much more fuel may be necessary to generate the amount of electricity for melting than is required when using the fuel direct. During recent years, however, considerable developments have been made in the use of electricity for melting both ferrous and non-ferrous metals.

In the metallurgical field great advances have been made in the manufacture of high grade metals and alloys, and it has been established that melting conditions are largely responsible for their quality. This field, therefore, has been given special attention by metallurgists in an effort to obtain a more controllable source of heat, both in regard to actual temperature and composition of furnace atmosphere and the extent to which electricity is now being used for metal melting is an indication that it is, in some measure fulfilling this need. To what extent electricity is being applied as a melting medium is best appreciated by reading this book which deals very comprehensively with the whole field of electric melting practice. The author does not burden the reader with descriptions of constructional details of plant, but discusses, in a very informative manner, metallurgical practice as carried out in electric-melting furnaces, but, where a new departure from previous practice has been made, no pains are spared in presenting the salient features of present-day installations.

The outstanding features of electric heating are a result of the fundamental nature of this heating medium. In the first place the heating of the charge does not depend upon external factors such as combustion, and—for a furnace of given electrical characteristics—heating conditions which are governed by the energy input, can be faithfully duplicated. The generation of heat is independent of the furnace atmosphere, which may be maintained at will reducing, oxidising, or inert. The input of heat, and consequently the rise in temperature, is adaptable to fine control, which in most cases can be automatic.

The initial chapters deal with the constructional features and the basic principles governing the metallurgical operation of arc furnaces for the manufacture of steel, for melting iron, and for non-ferrous metals. Steel melting in the arc furnace has been practised for twenty-five years, and its merits are well known. Within recent years its usefulness has been extended to the cast iron industry, where in some cases it supplements the cupola as a refining or superheating appliance, and in other cases produces synthetic irons, alloy irons and other irons for high-duty castings. The application of the arc furnace to non-ferrous metal melting is restricted to the metals and alloys of rather high melting points ; low temperature metals being more economically melted in resistance furnaces.

During the last few years the coreless induction furnace has been developed to a high degree of efficiency, and in the short time since its introduction it has become the standard melting equipment for high-alloy steel scrap, nickel-chromium alloys, high-speed steel, nickel-iron alloys, and other complex ferrous materials. In the non-ferrous field the vertical channel furnace is widely used. The adoption of electric melting as the author points out rests on certain economic facts, many of which are discussed in a manner which assists independent conclusions. The most important factor—that of attaining a high standard of quality—is stressed, and operating cost figures are cited with the object of showing what the various types of melting furnaces are capable of attaining.

There is a wealth of useful information in this book on the metallurgical aspects of metal melting and the descriptions and data on furnaces indicate the remarkable strides made in the ceaseless search for plant and technique to reach a higher standard of perfection in the initial stages associated with the manufacture of ferrous and non-ferrous materials. It should prove invaluable to all directly associated with the manufacture of metals and alloys. The author presents data in a very agreeable manner, and is to be congratulated on the production of so useful a book.

By A. G. Robiette, B.Sc. ; published by Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C. 2. Price 15s. net.

Metallurgical Analysis by the Spectograph

In the November, 1933, issue of this Journal, we published a review of a book under the above title. This publication embodied the results of work carried out by D. M. Smith, A.R.C.S., B.Sc., D.I.C., for the British Non-Ferrous Metals Research Association over a period of some eight years, and included a bibliography of the literature of the subject.

Although a relatively short time has elapsed since the publication of this work, many new papers bearing on the subject have appeared. The author has, therefore, incorporated references to these in a revised bibliography (up to March, 1935), which is now issued by the British Non-Ferrous Metals Research Association as a Supplement to the book under the title " Bibliography of Literature on Spectrum Analysis " (20 pp.).

Copies of the bibliography may be obtained from any bookseller or from the Secretary, British Non-Ferrous Metals Research Association, Regnart Buildings, Euston Street, London, N.W. 1. Price 1s. 6d. post free.

Some Recent Inventions

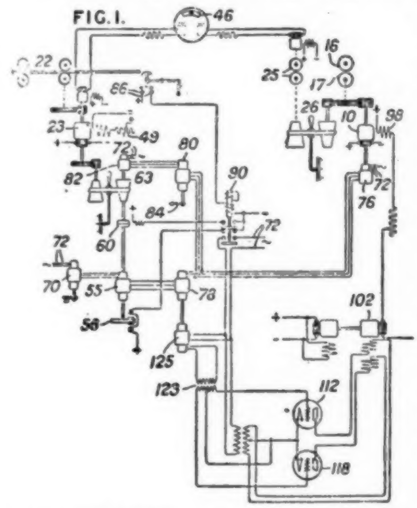
The date given at the end of an abridgement is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildinsg, London, W.C. 2, at 1/– each.

Rotary Shear Control in Rolling-Mill Plant

Much progress has been made during recent years in controlling various machines in modern rolling-mill plant. A recent development of this character has been effected in connection with an electrically driven machine designed for use in strip mills, such as a rotary shear for cutting lengths from bars of metal. It comprises means of causing temporary change of speed in the machine according to variation in the relative position so that each piece cut off will be of the same length. Shear blades positioned at 16 and 17 in the accompanying illustration, Fig. 1, are driven by a motor, the speed of which is varied as described by changing the strength of the field 98. The last finishing stand 22 and pinch rolls 25 are driven at equal speeds by means of a variable field resistance and tachometer comparison; the ratio between this speed and the speed of the shear is adjusted to determine the length of cut by a variable gear between the pinch rolls and the shear motor.

The relative angular positions of the shear motor and the motor driving the finishing rolls are compared by a differential receiving device comprising a three-phase rotor in a three-phase stator. The rotor of this device is energised from the three-phase stator of a position-sending device coupled to the shear motor and having a single-phase rotor energised from a source 72; the stator is energised from the three-phase stator of a position-determining device having a three phase rotor excited from a stationary device. The rotor of one device is held by electromagnetic means in a definite position so long as there is no strip material under treatment. Material entering operates a flag switch and a relay is thereby operated to de-energise the electromagnet and to energise a clutch coupling the rotor of the position-determining device to the motor to drive it at the speed of the shear. This drive is attained through variable-speed gearing 63 assisted by comparison means 80, 82 and pointer 84 which is stationary when the speed is correctly adjusted. If at the moment of presentation of the end of the material to the flag switch the shear blades are in correct position to cut the desired length from the strip, the single-phase rotor of a device 125 is held by the device 78 in non-inducing relationship to its single-phase stator; a disagreement in the relative positions of the strip and the shear blades will cause the device 125 to generate a single phase E.M.F. proportional to the difference, and this is applied through the transformer 123 to the grids of valves 112, 118 so that one or other is rendered conducting to an extent depending on the sense and degree of the positional disagreement. Thus, oppositely wound fields of a generator 102 are selectively excited and the field of the shear motor 10 varied to change the speed of the shear in such a manner that normal speed is resumed when positional agreement has been attained.

FIG. 1.



When the strip leaves the flag switch the relay 90 is de-energized and operates after a time delay to de-energise the clutch 60 and valve circuits and to energise the means 56 by which the position-determining device is held in its original position. An adjustment of the correcting means is obtained by manual rotation of the rotor of the device 70.

In a modification adapted for use when the distance between the finishing rolls and the shear is insufficient to give the necessary time for correction, the last finishing stand and the shear are driven by the motor 10, and rolls at sufficient distance from the shear are driven by the motor 23. The current rise in the motor 23 as the strip is introduced actuates a relay controlling the relay 90 and a separate time-delay opening relay arranged in the circuit of the latter. The variable-speed coupling between the motor 23 and the elements 60 and 28 is constitutee by a dynamo on the shaft of the motor 23 and a variable field motor driving the elements referred to.

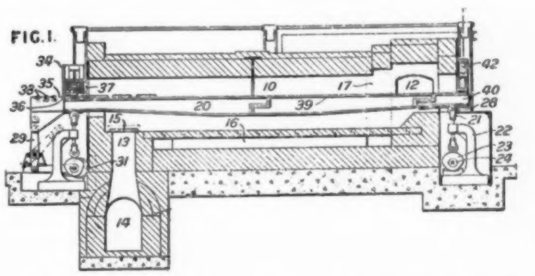
426,236. British Thomson-Houston Co., Ltd., Crown House, Aldwych, London. [Class 83 (iv.)].

Metal Heating Furnaces

Further developments have been made in a furnace designed for heating metal bars having a step-by-step conveyer comprising a pair of moving beams operating through slots in the furnace hearth, the front ends of the beams being formed with raised portions which, on the forward stroke, move through a stationary magazine 34 for the bars to be heated, the shoulders 36 carrying the lowermost bar or group of bars into the furnace.

During this charging stroke, the remainder of the bars in the magazine are supported by rollers 38 on the raised portions 35. The magazine is fitted, on the furnace side, with a vertically adjustable retaining plate and the raised portions 35 are also vertically adjustable so that the number

FIG. 1.



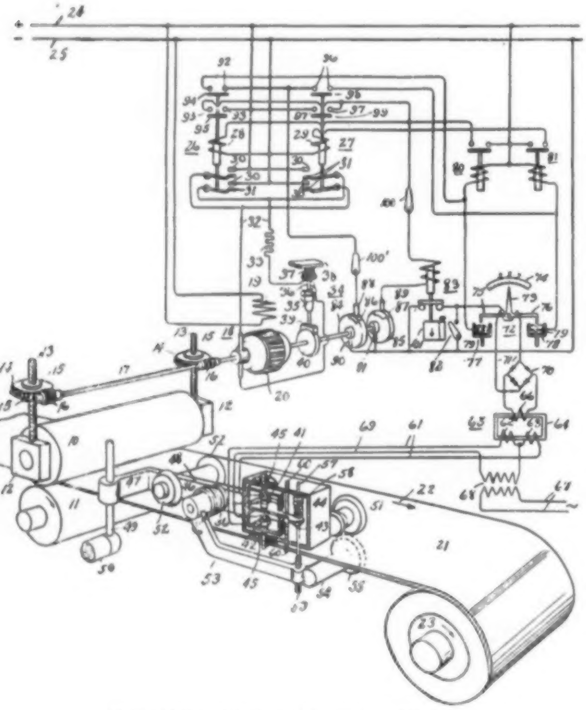
of bars carried into the furnace at each stroke can be varied. The beams are supported by rollers carried on pillars which are moved vertically in fixed guides by cams; the horizontal reciprocation of the beams is effected, through a pivoted lever, by an eccentric on the front camshaft.

In order that bars may be discharged from the furnace only when required, the motor driving the camshafts may be controlled by an automatic switch so arranged that, after being started up by a manually operated switch at the discharge end of the furnace, the motor is stopped when the conveyer beams have made one complete cycle. The manually operated switch may also actuate mechanism to effect the opening of the discharge door. Each conveyer beam is formed in three sections 20, 39, 40, the middle section 39 being formed of heat-resisting metal and the section 40 being insulated therefrom by asbestos or the like. The furnace is fired by a laterally disposed fireplace or gas producer delivering to the heating chamber 10 through a passage 12 to which is supplied, through a flue 17, secondary air heated in passages 16 below the hearth. The waste gases escape to the stack flue through passages controlled by dampers.

420,233. Gibbon Bros. Ltd., and A. W. Ogilvy-Webb, Dibdale Works, Dudley, Worcestershire. [Class 51 (ii)].

Controlling Thickness of Metal Strip in Rolling

Efforts have been made to devise mechanism which will enable the production of metal sheet and strip accurately to a predetermined thickness. In a recent development of this character variations in the thickness of metal strip from a predetermined value during the time of rolling, causes gauging rollers to move an armature 43 between inductance coils, so that the balance of a bridge formed by the coils and primary windings of a trasformer 65 is disturbed, and an indicating relay is energised from the secondary of the transformer and moves in one or the other



Controlling thickness in strip rolling.

direction to energise through the appropriate relay, one of two reversing relays, which cause a motor 18 to make an adjustment of the roll 10, and restore the thickness of the metal to the predetermined value.

In order to compensate for the distance between the rolls and the gauging rollers, the motor 18 is arranged to drive two segmental conducting discs, the first of which, on the initial movement of the motor, maintains the circuit of the energised relay 80 or 81 independently of the relay 72, and the second energises a relay 83, which opens the circuit of the relay 80 or 81, which passes through the relay 72. When the motor 18 has made one revolution, the disc 85 de-energises the relay 83, and the disc 84 de-energises the closed relay 80 or 81. The motor is, therefore, stopped, and cannot be restarted until after a time interval required by the relay 83 to close its contacts. This time interval allows the metal strip to pass a distance equal to that between the rolls and the gauging rollers, so that if the adjustment made by one revolution of the motor 18 is insufficient, as measured by the gauging rollers, the operation can then be carried out again. If this compensation is not required, a switch 100 is opened and a switch 82 closed. The time delay of the relay 83 may be adjusted in accordance with the speed of the metal strip by energising an auxiliary coil on the relay from a generator driven by the roll-driving motor. In a modification of the arrangement shown, in which the rolled material is magnetic, the gauging rollers are replaced by an arrangement using the metal itself as an armature affecting the coils 41, 42. In a modification of the means compensating for the distance between the rolls and the gauging point, the closed reversing contactor maintains itself independently of the closed relay 80, 81, through the relay 83, and also energises a relay, which after a time closes its contacts, to energise the relay 83, so that after the motor has run a certain time, it is stopped for a certain interval.

414,785. British Thomson-Houston Co., Ltd., Crown House, Aldwych, London. (Assignees of H. A. Winne, New York, U.S.A.)

Some Recent Contracts

Messrs. William Doxford and Sons, Ltd., recently received orders from Stephens, Sutton, Ltd., Newcastle, for three motor-cargo vessels, each of 9,200 d.w. capacity. They will be duplicates of Doxford's standard economy ships built and in course of construction for Messrs. Sutherland, Lord Runciman and Robert Ropner and Co.

The directors of the South Durham Steel and Iron Co., Ltd., through their subsidiary company, the Cargo Fleet Iron Co., Ltd., placed orders some time ago for mills for the production of steel billets, sheet bars, slabs, and rounds, and for a continuous mill for the production of wide strips of a width in excess of that at present being produced in this country. Following this initial development the directors of the South Durham Steel and Iron Company recently issued instructions for orders to be placed immediately for the necessary plant for the production of cold-rolled steel sheets also of a greater width than is at present produced in Great Britain.

The Southern Railway, it is understood, have placed contracts to the value of several million pounds for electrical equipment, in anticipation of future electrification. The orders which will be spread over a considerable period, have been placed with the English Electric Co., Ltd., and Asea Electric, Ltd.

The English Electric Company has a contract for the Southern Railway's requirements for electric train equipment, and Asea Electric Limited have received a similar contract for all the railway's requirements for high-tension switch gear and supervisory control apparatus. The contracts are among the biggest ever placed in this country.

Messrs. Harland and Wolff, Ltd., North Woolwich, London, have received orders from the Metropolitan Police for two-steel pontoons with deck houses, and from Messrs. W. Cory and Son, Ltd., London, for six steel swim barges to carry 160 tons and six steel hatched swim barges to carry 130 tons.

Messrs. The Stanton Ironworks Co., Ltd., near Nottingham, have secured an important order for large-diameter spun-iron pipes, to the value of over 50,000, from the Municipality of Skoplje, Yugo-Slavia.

Messrs. Richard Dunston, Ltd., Thorne, Yorkshire, have just received orders for the construction of eight steel barges for London owners, two petrol-carrying tank barges for service on the Thames, a steam-tug for Hull owners, and a Diesel-engined tug for service on the River Ouse. The barges will be built at Messrs. Dunston's Thorne Yard, and the two tugs at their associated yard, Messrs. Henry Scarr, Ltd., Hessle, near Hull.

Messrs. Vickers-Armstrongs, Ltd., it is stated, have been awarded the contract for the construction of a training ship for the Argentine Navy to replace the Presidente Sarmiento, which was built in 1898 by Messrs. Laird Bros., Ltd.

As part of the electrification of the Newcastle-on-Tyne to South Shields line, the London and North Eastern Railway Company have given an order to the Metropolitan-Cammell Carriage and Wagon Co., Ltd., of Saltley, Birmingham, for 131 steel coaches.

An order worth £500,000 has been placed in Britain by the West Australian Government for a power station at Perth which, when completed, will be one of the largest in the world with an output of 25,000 kilowatts. Most of the work will be carried out by International Combustion, Ltd., of Derby, and Parsons, Ltd. While orders will be placed in the North-Eastern areas around Newcastle.

Business Notes and News

Dorman Long Development

Considerable developments are being effected at the Cleveland Works of Messrs. Dorman, Long and Co., Ltd., Middlesbrough. Recent announcements of extensive additions alterations and improvements to mill equipment at these works are supplemented by a recent decision of the Company to install a cold-rolling mill and plant for the production of cold sheet and strip up to 72 inches in width. This decision is a natural development of the policy of the Board to operate plant at present idle, and, therefore, immediately available for the preliminary processes necessary for more highly finished steel products not manufactured in the country, for which there is a very considerable demand.

Some time ago Messrs. Dorman Long and Co., decided to erect at the Cleveland Works the largest single coke-even unit in this country, and the second largest in Europe. The contract, which has been placed is stated to amount to about £500,000.

North East Coast Institution of Engineers and Shipbuilders' Scholarship Awards

The 1935 Institution Scholarship, value £100 per annum, has been awarded to Harry Clifford Wilkinson, a student of marine engineering at the West Hartlepool Technical College and an apprentice at the Central Marine Engine Works, West Hartlepool. He will study at Armstrong College for the degree of B.Sc., in Marine Engineering. A prize of £5 is awarded to Anthony Gilchrist, who took a high place in the Scholarship Examination. Mr. Gilchrist is a student at Wallsend Technical College and an apprentice at the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne.

The Scholarship awarded last year to Mallinson Fowley is continued for a further year. Mr. Powley is reading for the Honours degree of B.Sc., in Electrical Engineering at Sunderland Technical College. He is an apprentice at the Sunderland Forge and Engineering Co., Ltd., Sunderland. The grant of £30 awarded last year to Richard Clement Sumner is continued for a further year. Mr. Sumner is studying for the degree of B.Sc., in Mechanical Engineering at Sunderland Technical College and is an apprentice of Messrs. William Doxford and Sons, Ltd., Sunderland.

The George Mitchell Harroway Scholarship, awarded in 1933 to Guy Gowland Harforth, is being continued for the 1935–6 session. Mr. Harforth is an apprentice of the Furness Shipbuilding Co., Ltd., Haverton Hill-on-Tees, and is studying at Armstrong College for the degree of B.Sc, in Naval Architecture.

Duty on Imported Silves Tubes

As a result of the termination of the International Tube Cartel the British industry is threatened with intense competition from foreign producers at cut prices and, in order to afford adequate protection in the home market, the Import Duties Advisory Committee has recommended additional import duties. Acting on this recommendation the following orders have come into operation.

Additional Import Duties (No. 24) Order, 1935, increasing the Customs duties on the cheaper grades of iron and steel tubes and pipes (other than cast tubes and pipes) from 20% (I.) where their value is less than £13 a ton to £5 per ton ; and (II.) where their value is £13 a ton or over but does not exceed £15 per ton to such an amount as equals the difference between the value per ton and £18. The duty on tubes and pipes of a value of more than £15 a ton and on all cast tubes and pipes remains unchanged at 20%.

Additional Import Duties (No. 25) Order, 1935, imposing a duty of 1½d. per pound, or 20% *ad valorem*, whichever is the greater, on tubing and piping manufactured partly of rubber, with or without nozzles or other fittings attached thereto, other than tubing and piping reinforced throughout its length with metal wire or strip.

Additional Import Duties (No. 26) Order, 1935, imposing a minimum specific duty of 3d. per 1,000, with an alternative of 20% *ad valorem*, on eyelets of metal (whether plated or coated or not), including tubular rivets with open ends and boot-hooks.

New Plant for Production of Diesel Oil

The first plant of its kind in the country for the production from British coal of Diesel oil for high-speed road transport engines is about to be erected at the Barugh works of Low Temperature Carbonisation, Ltd., near Barnsley. The new plant, said Colonel Whiston Bristow, chairman of the company, in an interview, is concerned in the first place with the extraction from the oil of the valuable tar acids contained therein and then with the conversion of the remainder of the oil into Diesel oil for high-speed Diesel engines. The whole of the process to be followed has already been developed in the laboratory, including a series of engine trials of the oil, with completely satisfactory results. The contract for the plan has been placed with Messrs. Simon Carves, Ltd., Cheadle Heath, Stockport.

Pact with Cartel

An agreement for a period of five years with optional break at three years between the British Iron and Steel Federation and the International Steel Cartel, was signed in London recently, and came into force early this month. The agreement provides for full collaboration between the parties on the regulation and development of the export markets and the protection of their respective home markets.

During the twelve months from August 8, the total imports into the United Kingdom from Cartel countries are not to exceed 670,000 tons, and for the four successive years thereafter are not to exceed 525,000 tons per annum. As compensation for the additional 145,000 tons in the imports for the first year, it has been agreed that should the total exports during that year exceed the total reached in 1934, two-thirds of such excess up to a maximum of 145,000 tons shall be allocated to Great Britain.

Agreement has also been reached as to the distribution of the total imports into the United Kingdom between the various products, but the allocation of export tonnage has yet to be settled. Provision is made that if a mutually satisfactory agreement is not reached by the end of the present year on any of the export agreements, the main agreement and any subsidiary agreements may be terminated by three months' notice.

The agreement is subject to the import duties on the products included being reduced to a level not exceeding 20% *ad valorem*. The provision of machinery for controlling the imports under such conditions is being worked out between the two parties. Pending the completion of this organisation, the Cartel have undertaken that provided the duties are reduced from August 8, the agreed rate of imports of the respective products during this period will not be exceeded, and the export quotas in the various products will also be given effect to as from August 8.

A co-ordinating or management committee has been set up for the proper carrying out of the agreement and for the general supervision of the sectional agreements to ensure that each conforms to the general policy and does not operate to the prejudice of others.

Stag Crushers and Granulators Reflect Improvement in Trade

The great improvement in trade which has been manifest during the last twelve months in this country is reflected in the order books of the Engineering Department of Edgar Allen and Co., Ltd., For example, during the last seven or eight weeks no fewer than twenty-six jaw crushers and jaw granulators have been ordered and are at the moment passing through the shops.

Considering that these machines represent only one small section of the machinery manufactured by this department, which includes tube mills, ball mills, cement-making plant. lime hydrators, rotary kilns, rotary dryers, etc., it is an interesting testimony to the improved conditions obtaining in British industry.

A copper data book, one of a series of books prepared for engineers, has recently been issued by the Copper Development Association. It contains a brief selection from the very large amount of data available, given in the form of an engineer's note-book, and is intended to act as a general guide in connection with applications of the metal copper. The data is presented in a very useful form, and a copy may be obtained gratis on application to Copper Development Association, Thames House, Millbank, London, S.W. 1.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100 0 0

ANTIMONY.

English	£75 0 0
Chinese	69 0 0
Crude	28 10 0

BRASS.

Solid Drawn Tubes	lb.	9¼d.
Brazed Tubes	„	11¼d.
Rods Drawn	„	8d.
Wire	„	7¾d.
*Extruded Brass Bars	„	4d.

COPPER.

Standard Cash	£31 17 6
Electrolytic	35 7 6
Best Selected	34 0 0
Tough	33 10 0
Sheets	62 0 0
Wire Bars	35 15 0
Ingot Bars	35 15 0
Solid Drawn Tubes	lb. 10d.
Brazed Tubes	„ 10d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 3 3
‡Ferro Tungsten	„	0 3 0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL: 2–4% Carbon, scale 11/- per unit	ton	29 15 0
NOMINAL: 4–6% Carbon, scale 7/- per unit	„	22 7 6
NOMINAL: 6–8% Carbon, scale 7/- per unit	„	21 12 0
NOMINAL: 8–10% Carbon, scale 7/- per unit	„	21 12 6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	34 0 0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36 5 0
§Guar. max. 0·7% Carbon, scale 12/6 per unit	„	37 5 0
‡Manganese Metal 97-98% Mn.	lb.	0 1 2
‡Metallic Chromium	„	0 2 5
§ Ferro-Vanadium 25–50%	„	0 12 8
§ Spiegel, 18–20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	6 5 0
20/30% basis 25%, scale 3/6 per unit	„	8 17 6
45/50% basis 45%, scale 5/- per unit	„	12 15 0
70/80% basis 75%, scale 7/- per unit	„	17 17 6
90/95% basis 90%, scale 10/- per unit	„	28 17 6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	13 10 0
§ Ferro - Carbon Titanium, 15/18% Ti	lb.	0 0 4½
Ferro Phosphorus, 20–25%	ton	15 15 0
§ Ferro-Molybdenum, Molyte	lb.	0 4 6
§ Calcium Molybdate	„	0 4 2

FUELS.

Foundry Coke—		
S. Wales	—	1 5 0
Scotland	—	1 8 0
Durham	0 19 0 to	1 2 0
Furnace Coke—		
Scotland	—	1 5 0
S. Wales	—	1 0 0
Durham	—	0 17 6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£44 0 0
*Commercial Ingots	40 0 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards .. lb.	0 0 9
*Cored Bars „	0 0 11

LEAD.

Soft Foreign	£15 15 0
English	17 15 0

MANUFACTURED IRON.

Scotland—	
Crown Bars, Best	£10 5 0
N.E. Coast—	
Rivets	10 10 0
Best Bars	10 2 6
Common Bars	9 5 0
Lancashire—	
Crown Bars	9 12 6
Hoops........£10 10 0 to	12 0 0
Midlands—	
Crown Bars	9 12 6
Marked Bars	12 0 0
Unmarked Bars ...... from	7 5 0
Nut and Bolt Bars .... £7 10 0 to	8 0 0
Gas Strip	10 12 6
S. Yorks—	
Best Bars	10 15 0
Hoops ...... £10 10 0 to	12 0 0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	9¾d.
†Sheet to 10 W.G.	„	11½d.
†Wire	„	11¾d.
†Rods	„	11d.
†Tubes	„	1/1½
†Castings	„	1/-

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—	
Hematite M/Nos.	£3 11 0
Foundry No. 1	3 12 6
„ No. 3	3 10 0
N.E. Coast—	
Hematite No. 1	3 8 0
Foundry No. 1	3 10 0
„ No. 3	3 7 6
„ No. 4	3 6 6
Silicon Iron	3 10 0
Forge	3 6 6
Midlands—	
N. Staffs Forge No. 4	3 7 0
„ Foundry No. 3	3 11 0
Northants—	
Foundry No. 1	3 10 6
Forge No. 4	3 2 6
Foundry No. 3	3 7 6
Derbyshire Forge	3 6 0
„ Foundry No. 1	3 14 0
„ Foundry No. 3	3 11 0
West Coast Hematite	3 7 0
East „ „	3 8 0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron Kr. 103	
Billets Kr. 240-310	£12 7 6–£16 0 0
Wire Rods Kr. 290-340	£15 0 0–£17 10 0
Rolled Bars (dead soft) Kr. 200-220	£10 6 0–£11 7 0
Rolled Charcoal Iron Bars Kr. 290	15 0 0

All per English ton. f.o.b. Gothenburg.
Converted at £1 = Kr. 19.40 approx.

SCRAP METAL.

Copper Clean	£27 0 0
„ Braziery	22 0 0
„ Wire	—
Brass	18 0 0
Gun Metal	25 0 0
Zinc	9 0 0
Aluminium Cuttings	66 0 0
Lead	13 10 0
Heavy Steel—	
S. Wales	2 15 6
Scotland	2 10 0
Cleveland	2 12 0
Cast Iron—	
Midlands	2 7 6
S. Wales	2 11 0
Cleveland	2 12 0
Steel Turnings—	
Cleveland	1 15 0
Midlands	1 14 0
Cast Iron Borings—	
Cleveland	1 5 0
Scotland	1 17 6

SPELTER.

G.O.B. Official	—
Hard	£11 15 0
English	15 7 6
India	13 0 0
Re-melted	14 17 6

STEEL.

Ship, Bridge, and Tank Plates	
Scotland	£8 15 0
North-East Coast	8 15 0
Midlands	8 17 6
Boiler Plates (Land), Scotland	8 10 0
„ „ (Marine) „	—
„ „ (Land), N.E. Coast	8 10 0
„ „ (Marine) „	8 17 6
Angles, Scotland	8 7 6
„ North-East Coast	8 7 6
„ Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 10 0
Light Rails ......£8 10 0 to	8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic ....£6 17 6 to	7 2 6
Medium Basic..£6 12 6 and	7 0 0
Soft Basic	5 10 0
Hoops..........£9 10 0 to	9 15 0
Manchester	
Hoops..........£9 0 0 to	10 0 0
Scotland, Sheets 24 B.G.	10 10 0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to $\frac{3}{16}$ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ⅛ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£211 0 0
English	211 10 0
Australian	211 10 0
Eastern	210 2 6
Tin Plates I.C. 20 × 14 box	18/2

ZINC.

English Sheets	£22 15 0
Rods	28 10 0
Battery Plates	—
Boiler Plates	—

*McKechnie Brothers, Ltd. Aug. 12 † C. Clifford & Son, Ltd., Aug. 12 ‡ Murex Limited, Aug. 12

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Aug. 12